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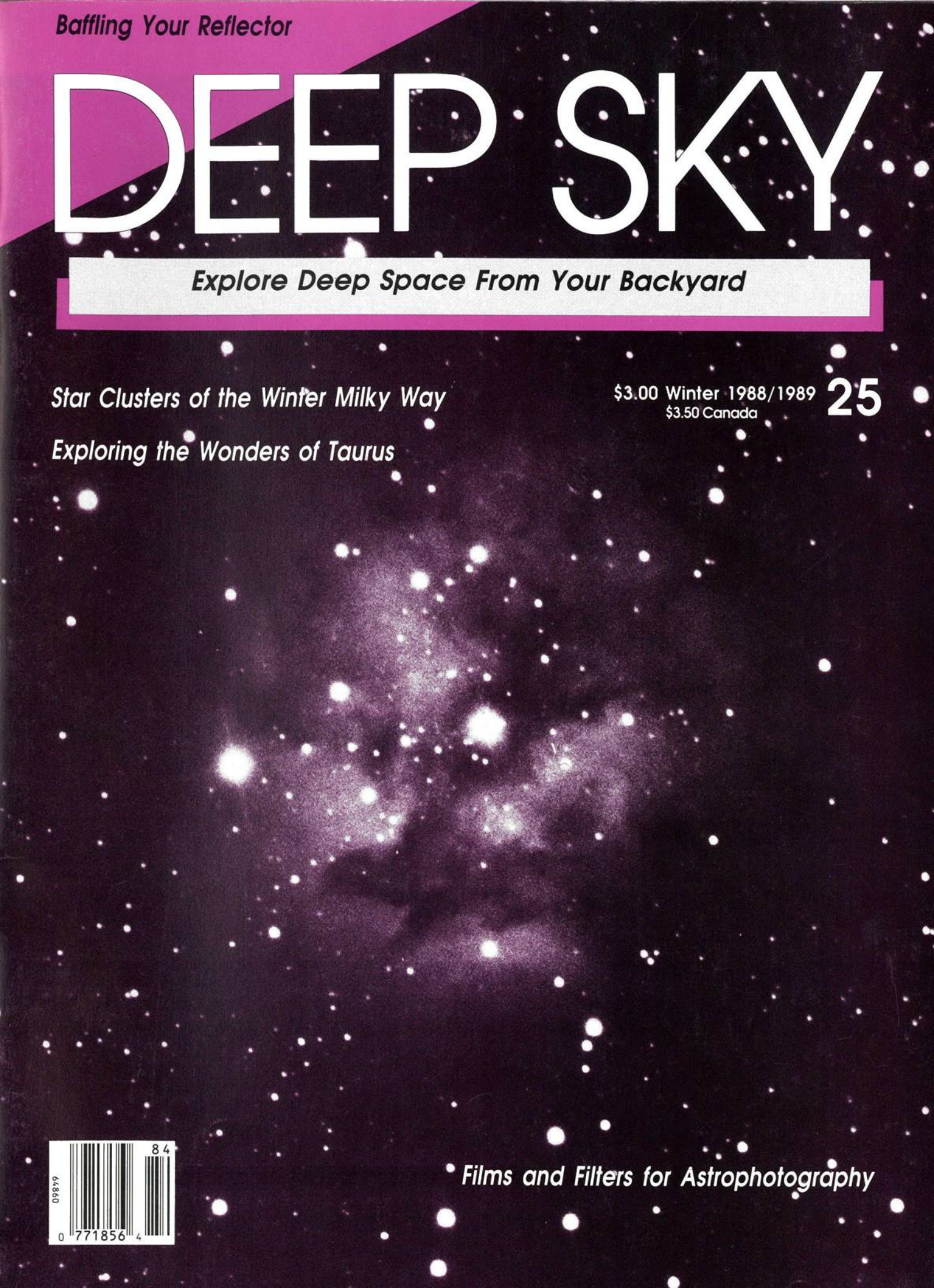

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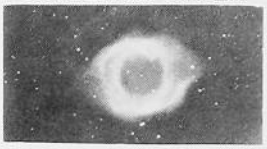

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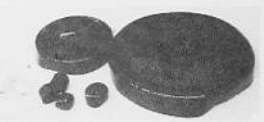

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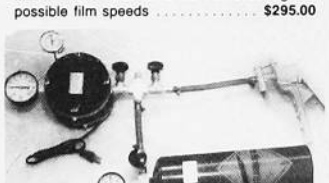

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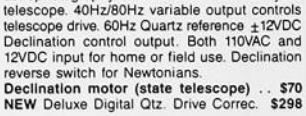

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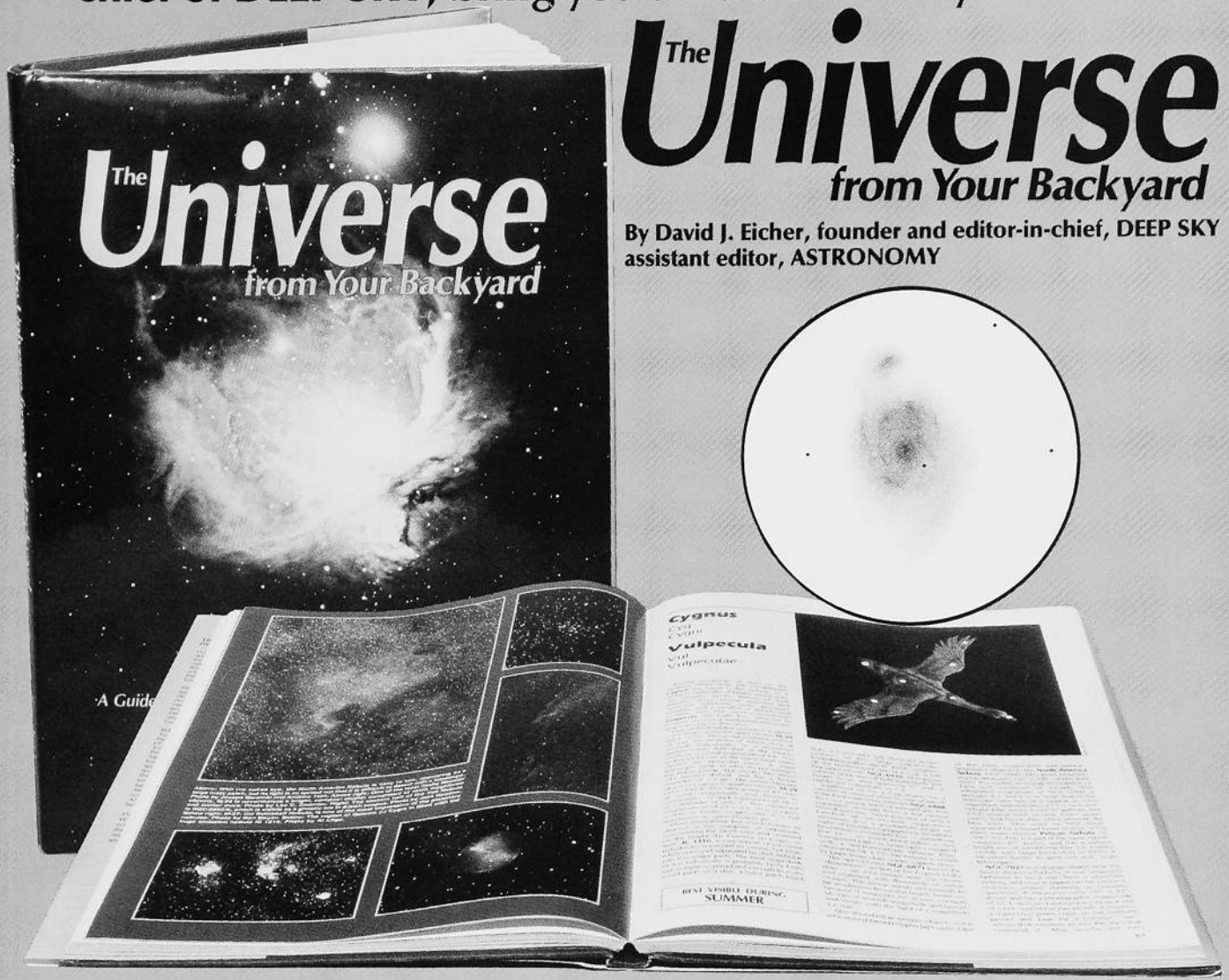

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By David J. Eicher, founder and editor-in-chief, DEEP SKY assistant editor, ASTRONOMY

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DEEP SKY

THE MAGAZINE FOR DEEP-SKY OBSERVERS AND ASTROPHOTOGRAPHERS WINTER 1988-1989 VOLUME 7, NUMBER 1

Star Clusters in the Winter Milky Way
by Bernard Abrams

10 *The graceful arc of light known as the winter Milky Way is studded with bright examples of open star clusters. Bernard Abrams takes you on a tour of thirty-four of the winter sky's best.*

Taking the Bull by the Horns in Taurus
by Phil Harrington

16 *Clusters, nebulae, unusual stars, and one very famous supernova remnant await you when you aim your telescope at Taurus the Bull.*

Films, Filters, and the Facts of Life
by Rick Dilsizian

22 *Some of the trickiest choices in astrophotography concern films and filters. Rick Dilsizian explains how to use the right film-filter combination for your sky and the objects you want to capture.*

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Cover: The Cocoon Nebula photographed by Kim Zussman with an 11-inch f/10 SCT, hypered Tech Pan film, and a 120-minute exposure.
Opposite page: The Pelican Nebula recorded by Martin C. Germano with an 8-inch f/5 reflector, hypered Tech Pan, and a 75-minute exposure.

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Letters to *Deep Sky*
Show Us Your Photos of NGC 891!

WANTED: Photos of NGC 891

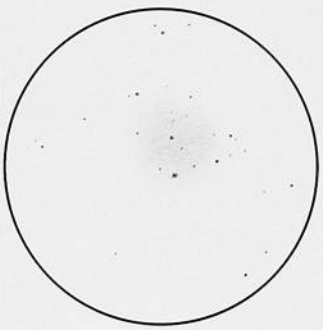
Attention astrophotographers! Steve Lucas of Midlothian, Illinois, has notified me that a research project regarding supernovae needs amateur assistance. "I have a request," wrote Steve, "for photographs of NGC 891. While I was at the IAU Pro-Am meeting in Baltimore this July, a fellow from Goddard asked me to help obtain images of this edge-on galaxy taken between December 1983 and December 1986. The photographs may contain information about the visual appearance of the galaxy involving supernova 1986J. The theories being studied indicate possible circumstellar absorption." Interested photographers with stock negatives of NGC 891 made during this period should contact Dr. Brad Schaefer, NASA Goddard Space Flight Center, Code 661, Greenbelt, MD 20771. — *DJE*.

Thanks to Corder, Higgins

Dear Dave / At a recent astrocamp in the mountains west of Brisbane, my friends and I had near perfect observing conditions over a long weekend. We had a great deal of fun in "discovering" the four brightest Palomar globular clusters with the Southern Astronomical Society's 12.5-inch Dobsonian. Thanks to David Higgins' excellent article, "Observing the Palomar Globular Clusters" (Spring 1988 issue), you enlightened us about a new group of objects. The same happened with Jeff Corder's piece on the Centaurus galaxy cluster — an excellent background read and good reference material on that fascinating corner of the universe.

To our pleasant surprise, both articles had very accurate drawings that looked very much like what I saw. One small difference was that the galaxies NGC 4696 and NGC 4709 appeared much more intense in their centers relative to the faint galaxies than Jeff's drawing suggested. Although the authors made their observations with much larger apertures (24 inches and 17.5 inches), we had no trouble seeing these objects because the sky was beautifully clear and the objects were high in the sky.

Both authors should be congratulated on preparing such well-researched articles that clearly demonstrated, through their drawings and descriptions, that they had observed all of these objects. Serious, well-presented articles like these are

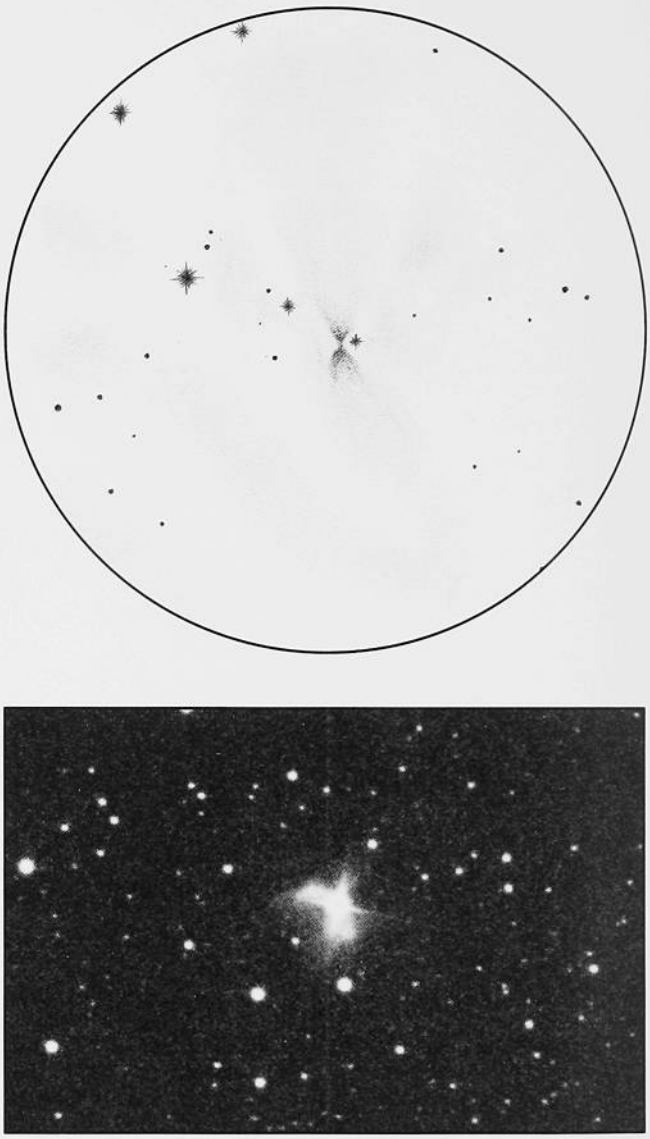


IC 4499 in Apus sketched by Gregg Thompson with a 12-inch f/4 reflector at 266x.

what deep-sky observing is all about!

While I was at the astrocamp, I had the opportunity to observe some other little-known objects that may interest your readers. One was the southernmost globular cluster included in *Sky Atlas 2000.0*, IC 4499 in Apus. It is too faint to see in my 12.5-inch scope from the outer suburbs of Brisbane but was plainly visible under dark mountain skies. As my drawing shows, IC 4499 was an unresolved, low surface brightness haze with no condensation and a few stars involved, most if not all of which were foreground objects.

Another unusual object was the so-called Toby Jug Nebula. Also known as IC 2220, the Toby Jug (equinox 2000 position: 7h56.8m, –59°08') is not plotted on *Sky Atlas 2000.0*.



Top: Thompson's Mystery Object, sketched with a 12-inch f/5 reflector at 330x. The field diameter is 13'. Above: IC 2220, the "Toby Jug Nebula," photographed by Steve Quirk with a 10-inch f/6 reflector, hypered film, and a 15-minute exposure.

The Toby Jug is rich in silicate dust grains and surrounds the old, cool, red star HD 65750. Curiously, the nebula appeared slightly more visible using an Hβ filter than the filterless view in the 12.5-inch scope. This is strange because the nebula is strongly red in color. The nebula's irregular shape verified it wasn't scattered light from the 6th-magnitude star.

I've enclosed a sketch of another mystery object for your readers to identify. This object's brightest portion has a high surface brightness that stands out brilliantly in a 10-inch or larger telescope. The central region has a bipolar structure, with dark nebulae to the east and west. Fainter nebulosity extends beyond the edges of the field, and the field is strewn with bright and faint stars. High magnification is required to see the struc-

ture of this interesting nebula. Although many observers have undoubtedly looked at this object, most of them seem not to have seen this bipolar structure. Who can identify this object?

Gregg D. Thompson
Springwood Observatory
7 Strover Court
Springwood,
Queensland, Australia 4127

Starstruck in Cygnus

Dear Dave / The other night I put a Lumicon UHC filter on my 26mm Plossl and stuck it in my Comet Catcher. As you know, the telescope is a 5.5-inch f/3.6 system. This is about as rich field as you can get! I wanted to see the North America Nebula. After aiming the scope, it was immediately apparent — quite a sight from my dark-sky location. Then, what should appear next to my wandering eyes? The entire Veil Nebula, big and distinct and ring-shaped. It looked like a big cosmic bubble. Now Dave, I've only been interested in astronomy as an adult since 1980 and have never seen this mentioned in print. If others would like a real astro-kick, I suggest they use a rich-field telescope and try it.

Ed Boutwell
Route 1, Box 41-B
Columbiana, AL 35051

Thanks for the tip on viewing really big objects, Ed. Readers will be interested to know that Ed's article on the ultimate deep-sky telescope will appear in an upcoming issue — DJE.

Mount Kobau a Success

Dear Dave / The annual gathering on Mount Kobau, British Columbia, is the Texas Star Party of western Canada. Between August 10 and 14, 1988, over two hundred amateurs gathered on this 6,000-foot hilltop during the Perseid weekend to observe and photograph under some of the darkest skies in Canada. In addition to Canadian amateur astronomers, the Mount Kobau event also attracts American astronomical groups from Washington and Montana.

This year's guest speaker was John Dobson. In addition to his interesting talks on telescopes and the universe, Dobson directed a number of people through the process of grinding and polishing a 10-inch mirror. In three days a complete telescope materialized, needing only a fresh coating of aluminum to catch starlight. Dobsonian telescopes were easy to find on Mount Kobau, with a huge 20-inch f/5 and a 36-inch f/4 from Tacoma, Washington, topping the list.

Southern British Columbia is known for its stable, mostly cloud-free weather pattern in late summer, and people take advantage of it: the choice spots for telescopes were taken a full week before the star party began. Although there were a few cloudy periods, those who persevered were rewarded with bright meteors, fine planetary details, fields overflowing with galaxies, and Don Machholz's new comet. See you next year at Mount Kobau!

Alister Ling
#303-16316-100 Street
Edmonton, Alberta T5X 5J6
Canada

Wonderful Nebula Filter

Dear Dave / This past year I came across something I want to share with the readers of *Deep Sky*. I bought an Enhanced Sky-Glow filter right after Orion Telescopes introduced it and have found this filter delivers pleasing results on a number of deep-sky objects and comets.

I first used the filter with an 8-inch Richest Field Telescope. Comet Bradfield (1987s) was my first test object. The ESG filter improved the view by showing a longer tail than was visible without the filter. Next I looked at the Pleiades cluster with a 24mm Konig and the ESG filter; nebulosity was immediately visible and appeared brighter and more detailed than I've ever seen from this location. The contrast effect produced by the filter helped show the nebulosity and didn't affect the image overall by knocking out faint stars and changing their colors.

The most astonishing object of the evening was the Andromeda Galaxy, M31, and its little companions M32 and NGC 205. The telescope's 1.5° field of view enabled me to fit all three objects in a single field except for the outer arms of M31. The view was tremendous with the filter, perhaps outdoing the view in telescopes twice the aperture. For the first time, I saw M32 embedded in nebulosity. Outer dust clouds in M31 appeared to be slightly three-dimensional. I have never seen this effect before.

Have other *Deep Sky* readers tried this filter?

Dan Sheber, Jr.
3240 Lancelot Lane
Green Bay, WI 54301

Observing the Palomar Clusters

Dear Dave / In August 1988 I vacationed in a dark sky site in Arizona. Being impressed with the darkness and clarity of the sky, I tried to observe some of the Palomar globular clusters (Spring 1988 issue). Equipped with an 8-inch SCT, I managed to observe four of the clusters: Palomar 7, 8, 9, and 11.

Palomar 7 is a relatively large cluster that appeared as a soft, round glow with a slightly brighter center. Palomar 8 has a pretty bright, oval center with a soft outer glow around it. Palomar 9 was the brightest and easiest to see, appearing as a small, round glow with an intense oval center. Palomar 11 was the most difficult of the four to find. It appeared as a small puff of nebulosity with a slightly brighter center.

Articles like the one on the Palomar clusters make *Deep Sky* special. Your magazine allows amateur astronomers to learn about and observe lesser-known objects that are just as fascinating as the bright objects. Keep up your outstanding work.

Dennis Casper
2701 Woodlawn Road
Sterling, IL 61081

Thoughts on Deep-Sky Observing

Dear Mr. Eicher / Here are a few thoughts on observing deep-sky objects that I hope your readers can relate to. I began making deep-sky observations in September 1984 with an 8-inch SCT from Essex Junction, Vermont. I soon moved all my activities to Williston. There Gary Nowak, Larry Garrett, Brad Vietje, Tom Yandow, Bob Williams, Jim Marciniak, and Paul Walker shared information on comets, asteroids, and astrophotography. Along the way I met others in print, like Walter Scott Houston and David Eicher who wrote of deep-sky observing and maintained my interest in it.

Besides the 8-inch telescope, I also used 4-inch, 6-inch, and 10-inch reflectors. Later I occasionally used 12-inch f/6 and 16-inch f/4.5 reflectors made by club members and spent a few nights on the Porter Turret Telescope on Breezy Hill at Stellafane. But the greatest telescope I've used, the real show-stopper, is the 9-inch f/10 Clark refractor at the Green Mountain Observatory here in Williston. The telescope was made in 1905 and its precision optics and massive mount make it a joy to use. My last logbook entry reads, "As of today, October 26, 1987, I have observed every deep-sky object on *Sky Atlas 2000.0* down to at least –15° declination with the 9-inch telescope."

Way back when, my first goal was to observe all the Messier objects. By April 1986 I had done so. About this time I had heard about so-called Messier Marathons, when in a single, wild night, observers saw all of the M-objects. However, this wasn't for me. I wanted to look at the objects carefully and record observations of faint NGC objects. At one point a cloudy night project began to emerge, and I compiled a list of all of the *Sky Atlas 2000.0* visible at latitude 45° north.

By now my favorite objects were galaxies and nebulae. Clusters were great too, especially globulars, but they didn't appeal to me as much as the "fuzzy stuff." My method of locating objects was pretty standard, a mixture of star hopping and right ascension sweeps. My method of preserving the moment was common too: white pencil on black paper. As I sought dimmer and dimmer objects, I found many surprises in them and also in brighter objects I reobserved. NGC 253 looked like a "southern sky Andromeda Galaxy." NGC 5907, a needle-thin spiral, was a beautiful sight. NGC 4565 in Coma Berenices became a favorite. I always enjoyed seeing the faint features of the Helical Nebula and bright color in the Saturn Nebula.

Enter *Uranometria 2000.0*. The most noticeable thing about this book is that 1° sections are marked and many faint stars included, so one can star hop us-

ing the main telescope's optics. The time I take finding objects and errors I make moving the telescope around have dropped significantly. Using *Uranometria 2000.0* has also shown me that it's time to move up from the 9-inch telescope, because

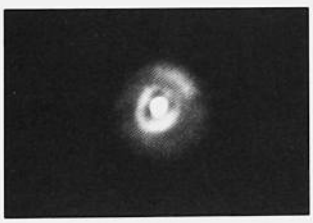
NGC 891. Rick Dilsizian photo (8-inch f/1.5 Schmidt, hypered Tech Pan, 8-minute exposure).

that instrument shows only about half of the objects on any page. I am planning a 17.5-inch scope with which I hope to investigate many new objects and also visit many old friends.

Russell Chmela
115 Sherwood Square
Essex Junction, VT 05452

Deep-Sky Observing with a Small Scope

Dear Dave / Living in Boulder, Colorado, has enabled me to

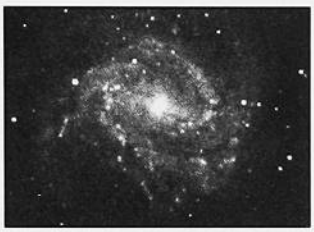


NGC 2392. Jack Newton photo (20-inch reflector at f/10, hypered Tech Pan, light pollution filter).

amass a collection of observing sites that range from around 5,000 to over 10,000 feet in elevation from the eastern plains up into the mountains. Couple this with clear, transparent nights and a good 8-inch reflector, and before you know it, you'll have a deep-sky fan.

Many people associate deep-sky observing with a large-aperture scope. While bigger scopes certainly help, there are still many deep-sky objects that reveal faint details in telescopes of 8 inches or less clear aperture.

I do much of my observing with the infamous "Views Brothers," Bob Spohn and Bob Ross of the Longmont Astronomical Society. These guys own the 13.1-inch and 17.5-inch versions of the Odyssey 8 that I use. Using their scopes gives me a lot of first-hand knowledge when it comes to comparing views in big and small mirrors. Although there are some exceptions, I can generally see everything they can. But the mega-



Galaxy M83 in Hydra. Martin C. Germano photo (8-inch f/10 SCT, 103a-F, 50-minute exposure).

mirrors bring out loads more detail. My routine is to search for objects that show impressive detail in small scopes. We all know about the big, obvious bright things that show lots of detail, so let's look at some lesser-known objects that also shine in small instruments.

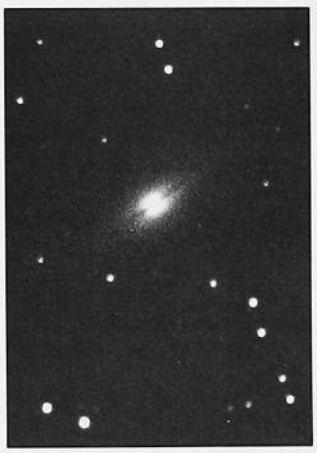
NGC 891 in Andromeda. *Burnham's Celestial Handbook* lists this object at magnitude 12.2, but it appears much brighter than that from my Gold Hill site. (*Sky Catalogue 2000.0* lists it at magnitude 10.0.) A 5-inch or 6-inch scope shows this galaxy and my 8-incher at low and medium powers reveals the hairline-thin dust lane. Be sure you are well dark-adapted before observing this one.

NGC 2403 in Camelopardalis. This bright, large spiral greatly resembles M33 in Triangulum and is one of the nearest galaxies beyond the Local Group. My scope shows a detectable mottling in the galaxy's spiral arms. Can anyone see this with a 6-inch scope?

The Whirlpool Galaxy in Canes Venatici. At magnitude 8.4, good old M51 offers the finest example of visible spiral structure in the sky. When describing the view of spiral structure with an 8-inch scope, Burnham uses the phrase, "with some uncertainty." I have never had this problem. The galaxy's large glow easily shows two bright arms and a dim, bridge-like structure that connects to NGC 5195. In the 17.5-inch scope the Whirlpool vaguely resembles a photograph from the U.S. Naval Observatory.

The Blackeye Galaxy in Coma Berenices. M64 is an easily observed galaxy that shows a large, dark dust cloud on the near-rim of its central bulge. This cloud has been observed by many observers with 6-inch telescopes and by John H. Mallas with a 4-inch reflector. I have never had trouble seeing the patch in my 8-inch scope.

The Eskimo Nebula in Gemini. NGC 2392 is a small, bright planetary known variously as the Eskimo or Clown Face Nebula. This object is bright enough to withstand high magnification (I typically use 200x). Its 10th-magnitude central star is plainly visible as is mottling in the nebula's shell that gives it "facial expressions." Big scopes show a hint of this planetary's color, although color perception varies wildly from observer to



NGC 7814 in Pegasus. Tom Eby photo (8-inch SCT at f/5.6, hypered Tech Pan, 45-minute exposure).

observer.

Globular cluster M92 in Hercules. I've included this well-known globular for two reasons. First, M92 is neglected because M13 is so near. Second, those who do look at M92 are treated to one of the most dazzling globulars in the sky.

Face-on barred spiral M83 in Hydra. Although this 8th-magnitude galaxy is low in the sky for Northern Hemisphere observers, it is large and bright enough to display spiral structure in an 8-inch telescope. Moderate powers (75x-100x) seem to work best.

Globular cluster NGC 2419 in Lynx. This object is one of the most distant globular clusters in the Milky Way. Despite its distance (93.1 kiloparsecs) and rather dim magnitude (10.4), NGC 2419 is an easily visible fuzzball that looks like a globular cluster. Don't bother trying to resolve this one — just enjoy it.

Reflection nebula M78 in Orion. Yes, there are other things to look at in Orion besides M42 and the Horsehead Nebula. When I first viewed this 8th-magnitude oddity, it looked like a comet with two bright stars as a double nucleus. A fan-shaped "tail" on this object is visible with all of the small tel-

Barnard 92. Martin C. Germano photo (8-inch f/5 reflector, hypered Tech Pan, 25-minute exposure).

escopes I've had the opportunity to try.

Spiral galaxy NGC 7814 in Pegasus. This magnitude 10.5 galaxy is a beautiful edge-on spiral showing a prominent central bulge and a thin equatorial dust lane. I was pleasantly surprised to see the amount of detail revealed in this object by an 8-inch scope.

Planetary nebula NGC 2438 in Puppis. This 11th-magnitude planetary is sometimes termed a difficult object for a small telescope. I have never had any trouble viewing it or showing it to a layman friend. Located on the northern edge of open cluster M46, it is so different in shape from surrounding stars that it stands out clearly.

Dark nebula Barnard 92 in Sagittarius. Possibly the best example of a dark nebula is B92, which sits right on top of the Small Sagittarius Star Cloud. This patch of dust is so dense it obscures our view of the heart of our Galaxy, the most star-crowded region we know.

Galaxy NGC 253 in Sculptor. The southern declination of this spiral does little to hurt its appearance at the eyepiece. I see lots of mottling and little dark lanes running through this object's arms. NGC 253 seems almost as big as M31. It's a fabulous object!

Next time you're feeling bad about how little you can see with your small scope, put it to the test: you'll be able to see detail in many more objects than you might have thought.

Tom Johnston
Longmont
Astronomical
Society
P.O. Box 8086
Boulder, CO 80501

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11. I certify that the statements made by me are correct and complete. (Signed) Sharon M. Drobinski, Office Manager.

At the Eyepiece
Call of the Pleiades

Remember the first time you saw the Pleiades? Standing on frozen ground and wrapped in layers of wool, your eyes marveled at the glistening dipper-shaped cluster in Taurus. There's something magical about observing the winter sky — what it lacks in Milky Way star clouds it more than makes up for in bright star clusters and nebulae. What it lacks in observing comfort it makes up for in crystal-clear transparency and rock-steady seeing. Many of the best views I've ever had have come under chilly winter skies. Therefore, when I gaze up at Orion rising in the east it sends a shiver up my spine — and more often than not the shiver isn't caused by Milwaukee's frigid temperatures.

This issue's feature articles take you on a tour of some of the best deep-sky objects in the winter sky. Bernard Abrams highlights thirty-four of the finest open clusters visible during wintertime in his lead article. Many of the photographs that appear in this article were taken by Abrams, an active member of Britain's Cotswold Astronomical Society. Taurus is this issue's featured constellation in "Taking the Bull by the Horns" by Phil Harrington. Phil's concise description of the fundamental parameters of each Taurus object will whet your appetite for braving the cold to see for yourself. Our last feature describes the tricky subject of using films and filters in astrophotography. In a world where the latest films and filters can dramatically improve your photos -- even relative to the "hottest" films of last spring — Rick Dilsizian's sage advice should come in handy.

Deep Sky 's winter departments cover a fascinating range of subjects. ASTRONOMY's Richard Berry describes the importance to both observers and astrophotographers of baffling Newtonians — a long neglected subject. A well-baffled Newtonian significantly outperforms nonbaffled ones: as Richard explains, the difference at the eyepiece is often striking. Also in the departments you'll find Tom Matty considering why we should observe open clusters, Jim Lawrence describing a useful technique for photographing eyepiece sketches, Alister Ling's "Small Scope Showcase," articles on double and variable stars by Brian Skiff and David Levy, and the return of Skiff's "Scanning the Literature."

Surely this will be a big, meaty package of stuff to enjoy while you're inside warming up from harsh winter weather.

Yours truly,

Dave Eicher
Editor-in-Chief

Star Clusters of the Winter Milky Way

by Bernard Abrams

Open clusters show the blend of immensity and delicacy that makes astronomy one of the most appealing sciences. From a coarse scattering of blue-white gems to powdery groups of faint stars, the winter Milky Way offers an almost endless variety of open clusters to any observer prepared to endure the long, chilly nights.

Thirty-four clusters offer challenges for all instruments, from binoculars to large Dobsonians, and plenty of targets for astrophotographers. While sweeping or photographing the Milky Way, you might be looking in the right place at the right time to discover a nova — there must be many missed each year that peak around magnitude 11 to 12. This could be a profitable sideline while observing galactic clusters.

Open clusters are relatively young. Many have existed for only a few million years, while others show no trace of the gas and dust from which they condensed 2 billion or 3 billion years ago. Born together, stars in an open cluster gradually gain their independence as the group is disrupted by external gravitational forces. Stars that remain form a cluster classified according to its appearance, with the degree of compression varying from "loose and irregular" (category "c") to "considerably rich and concentrated" (category "g") in the system developed by Harlow Shapley. Small telescopes resolve many open clusters. Dense showpieces like M37 provide a spectacular view that observers will return to again and again.

Astrophotographers can capture open clusters with a wide range of equipment. Within the limits imposed by a restricted field of view, slow systems with long focal lengths can be used as these extended objects are made up of point sources generally with high surface brightnesses. It's amazing how quickly the new, fast emulsions pick up open clusters — three or four minutes is enough with a moderate aperture if the object is reasonably bright. This is sufficiently short to leave a polar-aligned equatorial to itself, if the drive can cope, and gives freedom from sky fogging, even under moonlight.

The Double Cluster in Perseus is one of the most conspicuous features of the Winter Milky Way. Robert Reeves used a 300mm lens and hypered Tech Pan film. Opposite: Gem of the winter sky, Taurus' Pleiades cluster is visible as a clump of stars to the naked eye. Rick Dilsizian used an 8-inch f/1.5 Schmidt camera, hypered Tech Pan, and a 7-minute exposure.

As Pegasus moves into the west, Perseus rides high for observers in mid-northern latitudes. This is the home of one of the finest "doubles" in the sky, easily visible to the unaided eye away from city lights. Whether you know them as **NGC 869** and **NGC 884**, h and χ Persei, or simply the Double Cluster, these superb groups are curiously absent from Messier's list. With a separation of 45', both fit neatly inside a wide-field ocular.

At a distance of about 2.2 kiloparsecs the light from each cluster adds up to integrated magnitudes of 4.4 (NGC 869) and 4.7 (NGC 884). NGC 869 is slightly more compressed (Shapley class "f") than its companion ("e"). While the majority of visible cluster members are hot, luminous blue giants, there are a number of red stars in the region which add to the visual enjoyment. For an in-depth survey of the Double Cluster, see F. Michael Witkoski's article in the Fall 1986 *Deep Sky*.

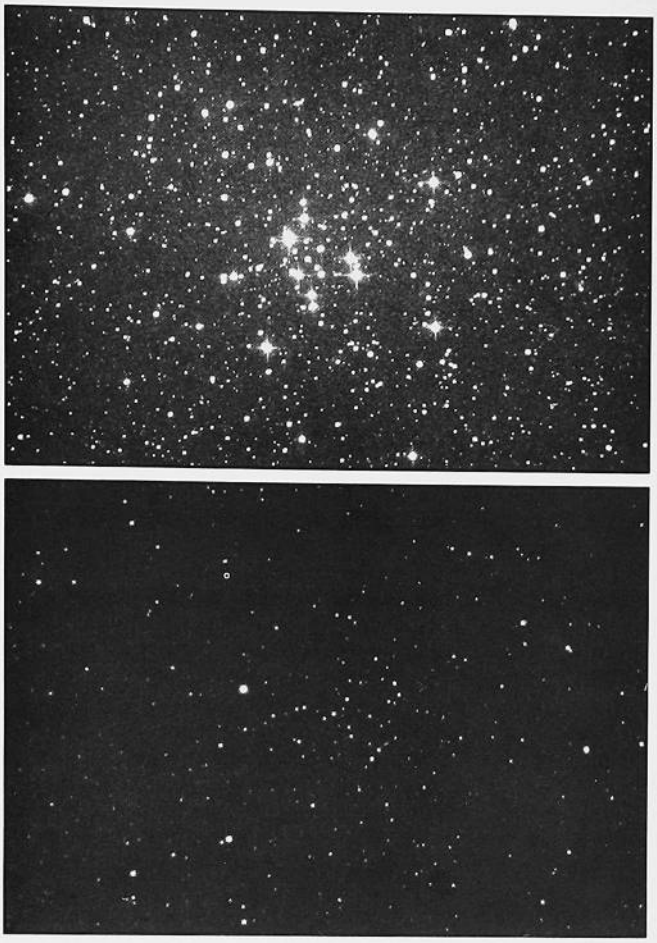
Three degrees southwest of h and χ is **NGC 744**, a 9th-magnitude collection of twenty-five stars spanning 10'. Situated due south of a magnitude 8 star, this cluster is often overlooked because of its more glamorous neighbors. Sweeping in right ascension underneath the Double Cluster will bring into view the relatively sparse **Trumpler 2**. Half a dozen stars spread over 20' in a rich area of the Milky Way can be quite difficult to identify — star hoppers should use the nearby trio of 7th-magnitude stars as a guide.

More impressive is **NGC 957**, an "intermediate rich" cluster packing over forty stars brighter than 15th magnitude into an area of sky 10' across. Lying 2.3 kiloparsecs distant, NGC 957 may be physically linked to the Double Cluster.

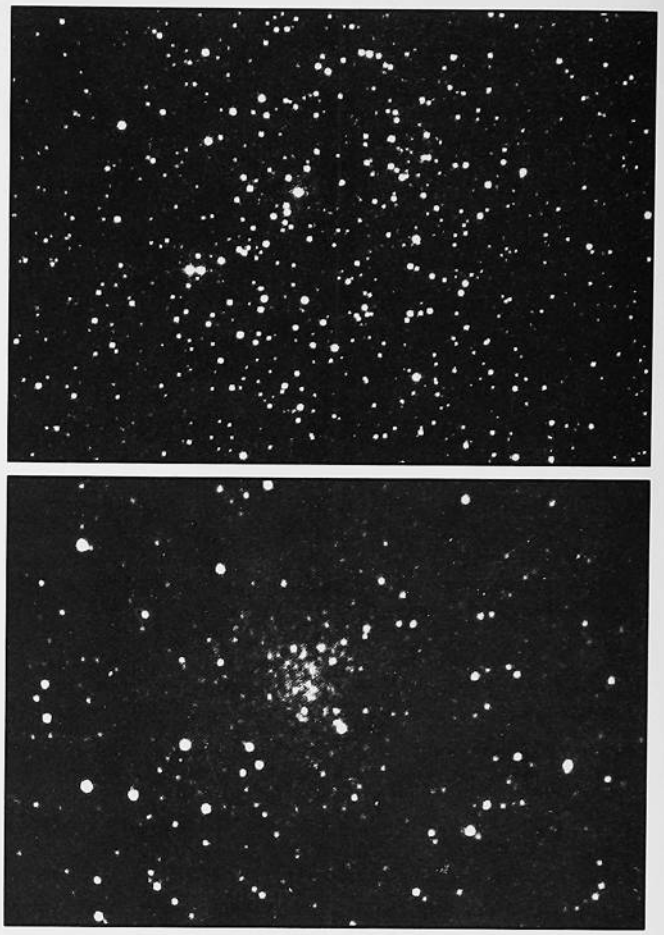
M34 (NGC 1039) provides a fine target for binoculars or small telescopes and is just visible to the naked eye from a dark site. It holds about twelve stars brighter than magnitude 9, with two doubles near the core. With a diameter approaching 1/2°, M34 registers well in telephoto lens portraits, while prime-focus shots reveal over eighty members of magnitude 7 and fainter.

Near the Perseus OB-3 group and 3° southwest of Mirfak lies **NGC 1245**. This compact cluster consists of fifty or so members of fairly even brightness. Stars of 11th magnitude and fainter combine to produce a circular glow 10' across. Visual impressions of such a condensed collection of powdery specks set against the Milky Way are always favorable. Try moderate powers for a delightful view.

Move across the region near Lambda Persei for a set of three contrasting objects, each with its own character. Most difficult is **NGC 1513**. My photos show two groups of stars connected by a bridge, both uniform and combining to produce an asymmetrical 9th-magnitude



Top: One of the finest clusters for binoculars, M34 in Perseus sports twelve stars brighter than ninth magnitude. Lee Coombs used a 10-inch f/6 reflector, 103a-O film, and a 10-minute exposure. Above: Diamond-shaped NGC 1664 lies 2° west of Epsilon Aurigae. Bernard Abrams used a 10-inch f/5 reflector, 1000 ISO film, and a 3-minute exposure.



Top: Larger than the Moon, Gemini's M35 is visible to the naked eye. Bernard Abrams used a 10-inch f/5 reflector, Tri-X film, and a 4-minute exposure. Above: Near M35 lies the more distant cluster NGC 2158, a tiny knot of stars difficult to resolve with small scopes. Bernard Abrams used a 10-inch f/5 reflector, Tri-X film, and a 4-minute exposure.

group. Brighter but more scattered, **NGC 1545** is centered on one of a group of four stars that straddle the galactic equator. It's easy to locate and has a number of yellow, bright stars set against twenty fainter companions.

The most impressive of the three, **NGC 1428** shows up as a 6th-magnitude granular haze covering nearly half a degree of sky. Any instrument from binoculars on up will provide a magnificent view in a 30' field. On color photographs one of the faint stars near the apparent center of the cluster is clearly redder than the rest, but this won't show up visually in anything but the largest amateur instruments.

Situated near Capella in Auriga, **NGC 1883** is the faintest cluster included in our tour. Fifteen stars span 4' to provide an unremarkable but challenging 12th-magnitude group that is roughly triangular in shape. This in no way sets the trend for things to come. Two degrees west of the enigmatic star Epsilon Aurigae lies **NGC 1664**, a diamond of stars with a "tail" stretching from one apex. At magnitude 7.5, thirty stars in a 15'-diameter group make up an intriguing collection worthy of observation.

At the heart of Auriga's pentagon and adjacent to a faint region of emission nebulosity, **M38** (NGC 1912) is one of those classic deep-sky objects. And because NGC 1907 lies nearby, M38 offers an aggregation of one hundred stars at magnitude 8 or below and a compact, 5' companion cluster. Telescopes of 6-inch aperture and above will show both well, while M38 is easily visible in a large finder scope.

Smaller and slightly more condensed, the 12' apparent diameter of **M36** corresponds to a real diameter of about 4 parsecs. This bright cluster, catalogued by Dreyer as NGC 1960, holds sixty stars between 9th and 14th magnitude including the pretty double Σ737.

Messier's list includes one more open cluster in Auriga. **M37** (NGC 2099) is my favorite and probably yours too. Here lie over 150 stars brighter than magnitude 13 in an area 20' across. This combination creates a stunning richness unrivaled in the winter skies. Set against a bright region of the Milky Way, M37 seems to melt into the background confusion of faint stars. Intrinsically larger and brighter than both M38 and M36, M37 presents a fine sight in any scope, with a red central star and numerous attendants.

Having once again enjoyed this selection of bright Messier objects, swing northeast from M37 past Theta Aurigae to **NGC 2192**, sandwiched between two 7th-magnitude stars. At a more demanding 11th magnitude, twenty-five stars occupying only 5' create a nicely condensed cluster that merits the "fairly rich" classification. Astrophotographers will have little difficulty acquiring a guide star when recording NGC 2281, situated near the northeastern boundary of Auriga. This 15' gathering shines at magnitude 6.7 and completes the selection of clusters from the Charioteer.

With Gemini approaching the meridian, our first stop is **NGC 2266**, 14° south of NGC 2281 and 2° north of Epsilon Geminorum. Although its diameter is a mere 4.5', thirty-five members between magnitudes 11 and 15 render the cluster visible in a 4-inch scope at medium power and very attractive with apertures of 10 inches and over. **NGC 2420** can be found between the irregular variable U Geminorum and the Eskimo Nebula. This collec-

E.E. Barnard's photograph of the Pleiades shows an incomparable amount of delicate, faint nebulosity. This wispy reflection nebulosity is visible in large backyard scopes.

Top: Sixth-magnitude NGC 1746 presents a pretty spray of stars in small scopes. Lee C. Coombs used a 10-inch f/5 reflector, 103a-O film, and a 5-minute exposure. Above: Centerpiece of Taurus, the Hyades is a naked-eye object and a fascinating region to scan with binoculars. J.A. Farrell used a 7.5-inch Schmidt camera, Royal Pan film, and a 5-minute exposure.

Top: NGC 2175 in Orion is surrounded by the faint nebula NGC 2174. Small scopes show the cluster without any nebulosity. Rick Dilsizian used an 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, and an 8-minute exposure. Above: Also surrounded by nebulosity is the cluster NGC 2244 in Monoceros. Bernard Abrams' photo approximates a small scope view.

tion of faint stars amounts to a 9th-magnitude glow spanning some 7'.

Dominating the region near the border with Taurus is magnificent **M35** (NGC 2168), very much a brighter cousin of M38. Both are characterized by lines and arcs of stars, a relatively vacuous center, and a smaller cluster nearby. At magnitude 5.3, M35 is visible to the naked eye on good nights, with 120 stars brighter than 13th magnitude. Its light is spread over 30', and there can be few better targets for binoculars and telephotos.

The region around M35 is full of faint stars and includes compact **NGC 2158**. At a distance approaching 5 kiloparsecs, this could be an intermediate cluster. On deep photographs it can appear more conspicuous than its partner, with 150 stars of 14th magnitude and below in a region 4' across. In the eyepiece of a small telescope, however, this translates into a small, 11th-magnitude circular patch of light.

Such a double act can be difficult to leave, but there are some equally exciting views ahead. Move 2° southwest to the edge of the boundary with Taurus to **NGC 2129**. Only slightly larger than NGC 2158, the total brightness of our present target is boosted by a triangle of 8th- and 9th-magnitude stars near the core.

As you move across into Taurus, the first cluster under scrutiny is **NGC 1647.** You will notice a large, scattered group of stars on telephoto shots of the Hyades as it sits beyond Aldebaran along one of the Bull's horns. A diameter of 45' can be difficult to contain (except with an RFT) and this object can lose impact by filling the field of view. Well worth a look, NGC 1647 is situated 500 parsecs distant and shines at magnitude 6.3.

These remarks also apply to **NGC 1746**, which lies farther out near the tip of the same horn. It holds fewer members, but those present are brighter and total 6th magnitude.

The **Hyades** (Melotte 25) form a familiar pattern on winter nights, with the 3rd-magnitude star Theta^2 Tauri forming part of the V-shape, which includes Aldebaran as a foreground object. With over 130 stars brighter than magnitude 9 stretching over 5°, the Hyades are best seen in binoculars and fit neatly inside the frame of a 135mm or 200mm telephoto lens.

Subject to even greater attention from both professionals and amateurs, the brilliant **Pleiades** cluster (M45, Melotte 22) needs nothing by way of introduction. The great debate over the number of naked-eye Pleiads rages on, as it always will through variations in visual acuity and local conditions, while the desire to record the Merope reflection nebulosity (IC 349) has spurned many an astrophotographer — including myself. Although some astronomers believe M45 isn't particularly young, many hold that the hot, B-type stars have formed relatively recently and are (in some instances) in the process of joining the main sequence. A less controversial anomaly is its omission from the NGC, a fate shared by the Hyades.

The final objects in Taurus are the twin clusters **NGC 1807** and **NGC 1817**. Separated by about 1°, the twins aren't identical. NGC 1807 covers 10', with between fifteen and twenty stars of 8th magnitude and fainter. It's an attractive sight in small telescopes. Larger (at 15') and with three times the population of its companion, NGC 1817 is a richer if slightly fainter cluster 1.8 kiloparsecs distant.

Top: M46 in Puppis is a rich cluster of faint stars that appears to contain the faint planetary NGC 2438, actually a foreground object. John Fletcher used a 10-inch f/6 reflector, Tri-X film, and a 4-minute exposure.

Top: M50 in Monoceros is composed of nearly one hundred stars in an area spanning 4'. Martin C. Germano used an 8-inch f/10 SCT, 103a-F film, and a 25-minute exposure.

On the way to more southerly constellations, stop for a while in Orion to view **NGC 2175**, an interesting combination of a galactic cluster with adjoining nebulosity (NGC 2174), which is bound to tempt photographers. Lying farther south and slightly east in Monoceros is **NGC 2264**. This is the Christmas Tree Cluster, home to forty loosely grouped stars, a large number of T Tauri variables, and the famous Cone Nebula. The entire region around S Monocerotis is filled with detail in long-exposure photographs, but try large binoculars for an appreciation of the group's nickname as its 6-parsec diameter fills half a degree of sky.

Another favorite for Schmidt camera owners, the Rosette Nebula is host to **NGC 2244**. These young stars appear to have created a nest for themselves inside the tenuous clouds of gas. The brightest members are arranged in pairs, with a combined magnitude of 6.2, and are well seen in binoculars.

Two degrees north of the Rosette past AX Monocerotis lies **NGC 2236**, a rich knot of fifty stars packed into a region only 5' across. With total brightness just short of 12th magnitude, it appears as a hazy patch in the winter Milky Way. Much brighter at magnitude 5.8 is the 15' cluster **NGC 2301**. Situated 1/2° from the galactic equator, its fifty members form a loose arrangement (Shapley "d"), which shows up well at low powers.

Out of 1,250 observations made over two years for the Cotswold Astronomical Society's Messier league, thirty members based at Cheltenham, United Kingdom, have logged **M50** (NGC 2323) twelve times. As a large, rich, and bright group of one hundred stars, it's well worth a look as one of the Unicorn's most attractive clusters. It has a diameter of 4' and is situated just under 1 kiloparsec away.

The remaining clusters are well placed for observers in more southerly latitudes. Four degrees south of Sirius is another fine Messier object visible in binoculars as a 1/2° circular haze. **M41** (NGC 2287) sits just north of 6th-magnitude 12 Canis Majoris. A bright, K-type giant is situated at the center of the cluster, with over fifty companions that make M41 visible without optical aid under suitable conditions. The distance to the cluster is just over 1 kiloparsec.

Tightly grouped, the stars of **NGC 2360** shine at 9th magnitude against a very rich background and cope well with moderate to high magnification. We are now in the northeastern corner of the Great Dog near the bright clusters **M46** (NGC 2437) and **M47** (NGC 2422) in Puppis. The former is well known because of the planetary nebula that appears to surround one of its members. With an apparent diameter of 65", the 11th-magnitude planetary is thought to be a foreground object placed "inside" M46 by line of sight. The cluster itself, discovered by Messier in 1771, contains over 150 stars and appears as a rich, homogeneous, and attractive object. Six-inch and larger instruments provide a fine view, and both NGC 2438 and M46 are easy to record photographically.

Less than 2° to the west, **M47** is a much closer group that presents a mixture of bright and faint stars across a 20' diameter. With a total magnitude of 4.6 it can be seen with the naked eye. Small telescopes show a delightful variety of colors among the twenty-five-plus cluster members.

Melotte 71 presents a challenge near the boundary with Monoceros. Only 8' across, over sixty stars give the cluster a richness matched by few others in the vicinity. **NGC 2539** is easy to locate and almost as condensed as Melotte 71. At magnitude 8 it can be found with large binoculars.

Rising to an altitude of 20° from latitude 52°N, **NGC 2432** can be difficult to locate on nights when the transparency is less than excellent. Hidden from my permanently sited 10-inch refractor, I rely on a portable SCT for a view of its faint collection of fifty stars at magnitude 10 and below.

Marking galactic longitude 240°, **M93** (NGC 2447) is the most southerly Messier object in my observing log. With a total brightness amounting to magnitude 6, it should be visible to a sharp eye when overhead under dark skies. A compact object, M93 is populated by over sixty stars between 8th and 13th magnitude in an elongated arrangement 18' across.

Those fortunate enough to get good views of the magnificent M93 won't need much prompting to take another look. One day I hope to share the experience — but for now, with Leo heralding the dawn and prompting thoughts of spring galaxies, it's time to retire. And if, like me, you're likely to remain awake for some time yet researching the objects you've just observed or photographed, the enjoyment of these clusters will continue long after sunrise.

Bernard Abrams lives in Cheltenham, England.

TAKING THE BULL BY THE HORNS IN

TAURUS

by Phil Harrington

As autumn fades into winter and temperatures plummet, temperate latitudes receive frequent rushes of cold air that sweep our atmosphere clean. In place of the haze and smog we have become accustomed to gazing through dark skies set ablaze by bright stars.

Mighty Orion dominates the scene, teamed with his faithful hunting dogs Canis Major and Canis Minor. Looking on, standing on the gentle rifts of the winter Milky Way, are the Gemini twins, with Auriga the Charioteer standing to their side. Below Auriga, seemingly taunting Orion into action, is the fiery bull Taurus. Many splendid deep-sky objects in Taurus provoke deep-sky observers into action. Dazzling open clusters, wispy nebulae, and even a few distant galaxies all await patient telescopes and eyes.

Aldebaran represents the eye of Taurus the Bull. Studies show it is a K5 giant star about forty times the diameter of the Sun. Its apparent magnitude of +0.85, when combined with a distance of 21 parsecs, means an absolute magnitude of -0.3. This is about 125 times brighter than the Sun. Aldebaran lies in the foreground of the **Hyades**, which make up the rest of Taurus' head. The Hyades, also catalogued as Melotte 25, lie about 46 parsecs away, which places the group closer than any other known cluster except the Ursa Major Moving Group.

Easily resolvable with the unaided eye, the Hyades are a bright, easy star group. The cluster's appearance is quite attractive through finder scopes and binoculars. Of the hundreds of members within the Hyades, 132 are brighter than 9th magnitude and therefore visible in binoculars. The brightest star in the Hyades is Theta^2 (θ^2) Tauri, which shines at magnitude 3.3. It teams with magnitude 3.9 Theta^1 (θ^1) Tauri to form a wide, easy naked-eye double.

NGC 1647 is a large cluster easily visible in binoculars. It lies northeast of the Hyades cluster (right). Janos Papp photo (135mm f/2.8 lens). Opposite page: Large scopes reveal filamentary structure in the Crab Nebula. Neyle Sollee photo (24.5-inch SCT, hypered Tech Pan, 45-minute exposure).

The Hyades mark a central reference point for a survey of other Taurus objects. Scanning southward, we move off the plane of the Milky Way and begin to look into intergalactic space. Of the more than thirty galaxies in Taurus, two out of three lie in this region. Most are visible with 6-inch or larger instruments.

The brightest galaxy in Taurus is **NGC 1587**, one of four galaxies nestled in a group just 45' north of 45 Eridani. Shining with the light of a 12th-magnitude star, this E1 elliptical stood out surprisingly well in my 8-inch f/7 Newtonian at 84x.

Under the typical mediocre skies from my backyard, the other three galaxies in the NGC 1587 group eluded the 8-inch telescope. **NGC 1589**, an Sb spiral, is only half a magnitude fainter than NGC 1587. But because it measures 3' by 1.5', NGC 1589's surface brightness is much lower. For the same reason, 13th-magnitude **NGC 1588** appears more prominent than its larger neighbor. This E1 elliptical is located just south of NGC 1587. The final galaxy in the set, **NGC 1608**, lies farther to the east. Only the largest amateur telescopes will reveal this faint galaxy.

Once you have examined these four galaxies, aim your telescope at NGC 1587, turn off the clock drive, and let the stars drift across the field for twelve minutes. Doing so will place **NGC 1642** into view. This little known Sc spiral has a photographic magnitude of 13.6 and measures 2' by 1.8'.

To the north lies **UGC 3128**, a 14th-magnitude S(B)0 galaxy. Its 1'-diameter halo is difficult to spot because no bright stars lie nearby. **UGC 3087**, on the other hand, is surrounded by a trapezoid of 6th- and 7th-magnitude stars. Classified as an S0 galaxy, its 14th-magnitude disk measures less than 1' across.

From UGC 3087's stellar trapezoid, continue northward past a pair of 8th-magnitude stars to **NGC 1590**. At photographic magnitude 14.6, this peculiar galaxy will appear minuscule unless viewed with high powers on steady night.

NGC 1409 and **NGC 1410** form an intriguing pair of interacting galaxies. The former is an S(B)0p system, while the latter is an Elp galaxy. Together they shine at 14th magnitude and measure a mere 1.3' by 1' across. Fortunately a 6th-magnitude star lying 20' to the northwest aids in finding this target. Once again, high powers are a must for viewing any of these faint systems.

A little less than 2° north of the Hyades lies an object back in our Galaxy, the erratic variable star **T Tauri**. This star's unpredictable behavior carries it between 9th and 13th magnitude. At times T Tauri maintains a steady light for months, while at other times it suddenly flashes across its full magnitude range in a matter of weeks.

Surrounding T Tauri is a nebulous object catalogued as **NGC 1555**, popularly known as

Hind's Variable Nebula. Both the variable star and the nebula were discovered in 1852 by the British astronomer John Russell Hind. He described the cloud as viewed through his 7-inch refractor as extremely faint, less than 30' across, and positioned 40" southwest of the star.

During the decade following Hind's discovery unusual changes in the object occurred. By 1861 Hind's Variable Nebula had diminished in brightness perceptibly, and by 1868 the nebula disappeared. Twenty-two years elapsed before it was next seen. This time E. E. Barnard and S. W. Burnham spotted it through Lick Observatory's great 36-inch refractor. The nebula vanished again by 1895, only to be recovered photographically in 1899. The cloud's variations have been regularly monitored since then.

Since Hind's discovery, the nebula has not only fluctuated in brightness but also in size and shape. Currently it is visible just west of T Tauri. Astronomers believe NGC 1555 is the brightest portion of a luminous shell of gas surrounding the variable star T Tauri.

Authorities differ on the visibility of Hind's Variable Nebula. Some, such as *Burnham's Celestial Handbook*, insist that the nebula has continued to brighten over the past half century. Walter Scott Houston has spotted it faintly through his 4-inch Clark refractor at 150x. Other references, such as the *Webb Society Deep Sky Observer's Handbook*, maintain it is currently very difficult to see. Webb Society member David A. Allen found it "only visible with averted vision with T Tauri out of the field" with Mount Wilson's 60-inch telescope. I have never seen this object with my 8-inch or 13.1-inch f/4.5 reflectors, even under reasonably dark skies.

Open cluster **NGC 1647** is a far easier target. Located 3° northeast of Aldebaran, NGC 1647 contains two hundred stars, the brightest shining at magnitude 8.6. The number of stars in NGC 1647 grows to over five dozen points of light in my 13.1-inch scope. The stars fill a 45' area, so low magnifications generally provide the best view.

Only large backyard instruments will reveal our next target. **NGC 1615** lies about 2.5° northwest of NGC 1647 and only several arcminutes east of a pair of 7th- and 8th-magnitude stars. Listed as a magnitude 15.0p S0 galaxy, NGC 1615 is easily overwhelmed by starlight from the double star if not sought under optimum conditions. A telescope equipped with a high quality, short focal length eyepiece just might reveal it. Look for the subtle glow of the galaxy's central core surrounded by a dim halo measuring only 1.6' by 0.9'.

Lying near the Taurus-Orion border are two easy open clusters. **NGC 1807**, the brighter of the two, glows at magnitude 7.0 and contains twenty stars. This cluster's apparent diameter is 16', which makes it easily visible in small scopes. **NGC 1817**, a magnitude 7.7 object, lies just to the northeast. This group hosts sixty stars across a 17' diameter. My first encounter with this galactic duo came back in 1970 when I spotted them through my first telescope, a 2.4-inch refractor. My rather primitive notes from that era describe NGC 1807 as moderately rich with many bright stars. At the time I failed to note the cruciform shape of the cluster that so many other observers record in their notes.

NGC 1817 was a much less distinct object. My refractor could show only a few of its brightest stars, which shine at 10th magnitude. The other cluster members, most brighter then 14th magnitude, were lost in a hazy glow. An 8-inch scope under dark skies shows dozens of stars, while the 13.1-inch instrument shows the faintest members even under suburban skies.

To the north lies **NGC 1746**, a scattered open cluster visible to the naked eye on dark nights. Twenty stars give this object an overall magnitude of 6.1. Several of the brightest stars are visible through binoculars. My 4.25-inch f/4 reflector produced a pleasant view of twenty-six stars set within 45', while a 6-inch scope shows about three dozen stars.

When viewing NGC 1746, notice how many stars seem unevenly clumped toward the east. Many early observers noted this effect. When compiling his *New General Catalogue*, J. L. E. Dreyer chose to list the more densely populated eastern portion as **NGC 1758**. Similarly, a smaller, more centralized set of stars was identified as **NGC 1750**. In reality, however, all three designations refer to a single cluster in space.

IC 2087 is a faint reflection nebula measuring 4' across within a triangle of 6th- and 7th-magnitude stars about 3° north of Tau Tauri. While no illuminating star has been identified for this pale object, the nebula is associated with the dark cloud **Barnard 22**. B22 is one of over a dozen dark nebulae found in this region. Collectively they form long, narrow lanes stretching roughly east-west and measuring 600' by 20'.

Of all the sights that Taurus holds, none is more beautiful than M1 (NGC 1952), the **Crab Nebula**. The Crab was discovered in 1731 by John Bevis, an English physician and amateur astronomer. Twenty-seven years later, its accidental discovery by Charles Messier proved the event that began Messier's catalogue of deep-sky objects. When he first encountered the Crab Nebula, Messier felt certain he had discovered a new comet. Night after night he watched the curious object for any telltale movement against the background stars, but it stayed put. Finally Messier was forced to conclude that he had not seen a comet after all; instead this nebulous patch must lie beyond the solar system.

Calling his first entry "M1," Messier began a list of all the comet-like objects he and his contemporaries encountered through their telescopes. Later Messier wrote:

What caused me to undertake the catalog was the nebula I discovered above the southern horn of Taurus on September 12, 1758. This nebula had such a resemblance to a comet that I endeavored to find others, so that astronomers would not confuse these nebulae with comets just beginning to shine.

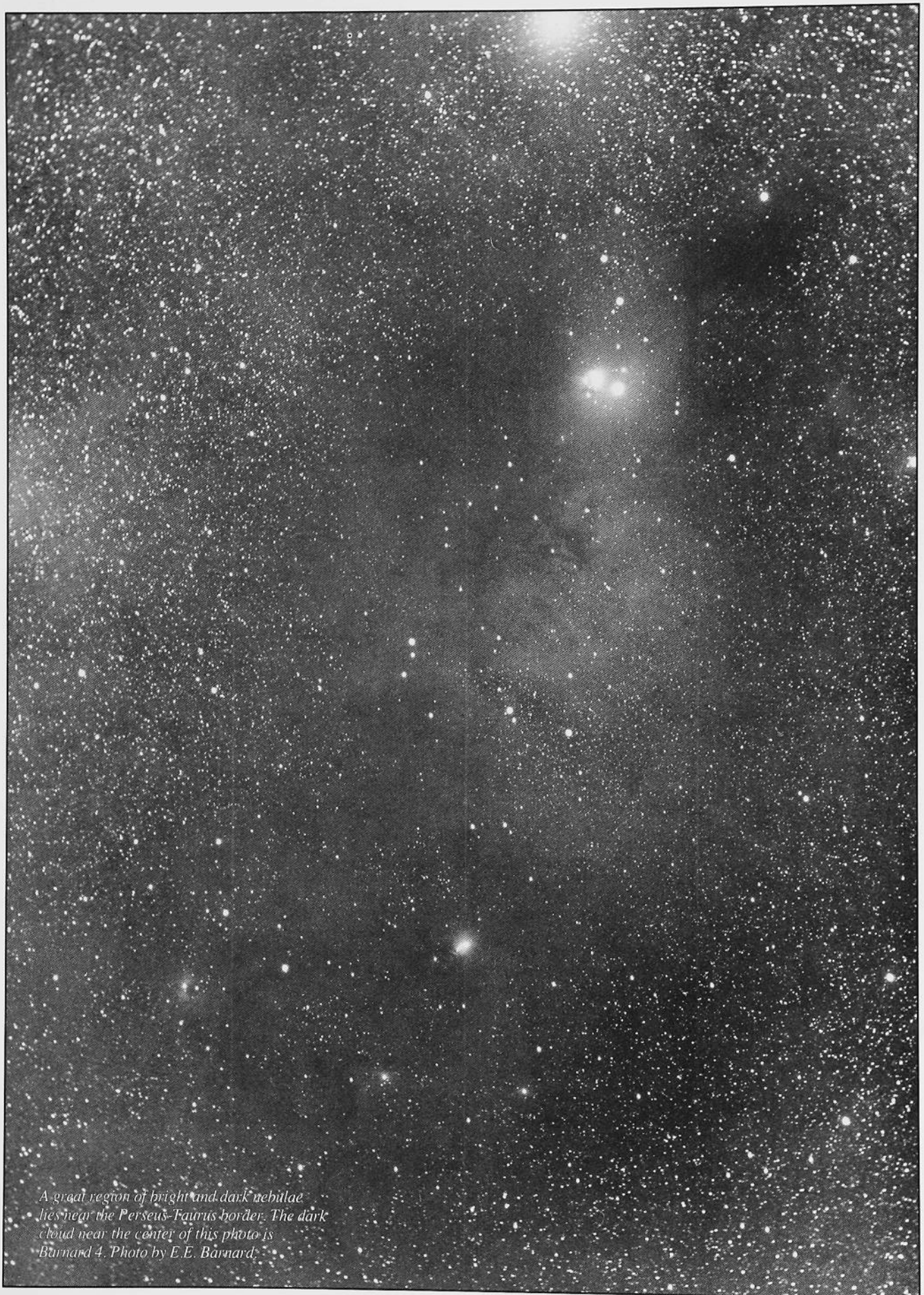
The story of the Crab Nebula began nearly seven hundred years earlier in A.D. 1054. On July 4 of that year, Yang Wei-Te, the imperial astronomer to the Chinese court during the Sung dynasty, and others observed a dazzlingly bright star in the east early that morning. It outdazzled anything Yang had ever seen in the night sky. In fact, it was so bright that this "new star" was visible in broad daylight over the entire summer and did not fade from visibility until a year after its initial outburst.

Today we know that Yang witnessed one of the universe's most striking and devastating events: a supernova. In a supernova explosion the core of a very massive star collapses. Tremendous energy is suddenly and violently released, blowing the star apart. After the explosion all that remains of the this once-great stellar luminary is a small, incredibly dense neutron star and an expanding cloud of gaseous debris called a supernova remnant.

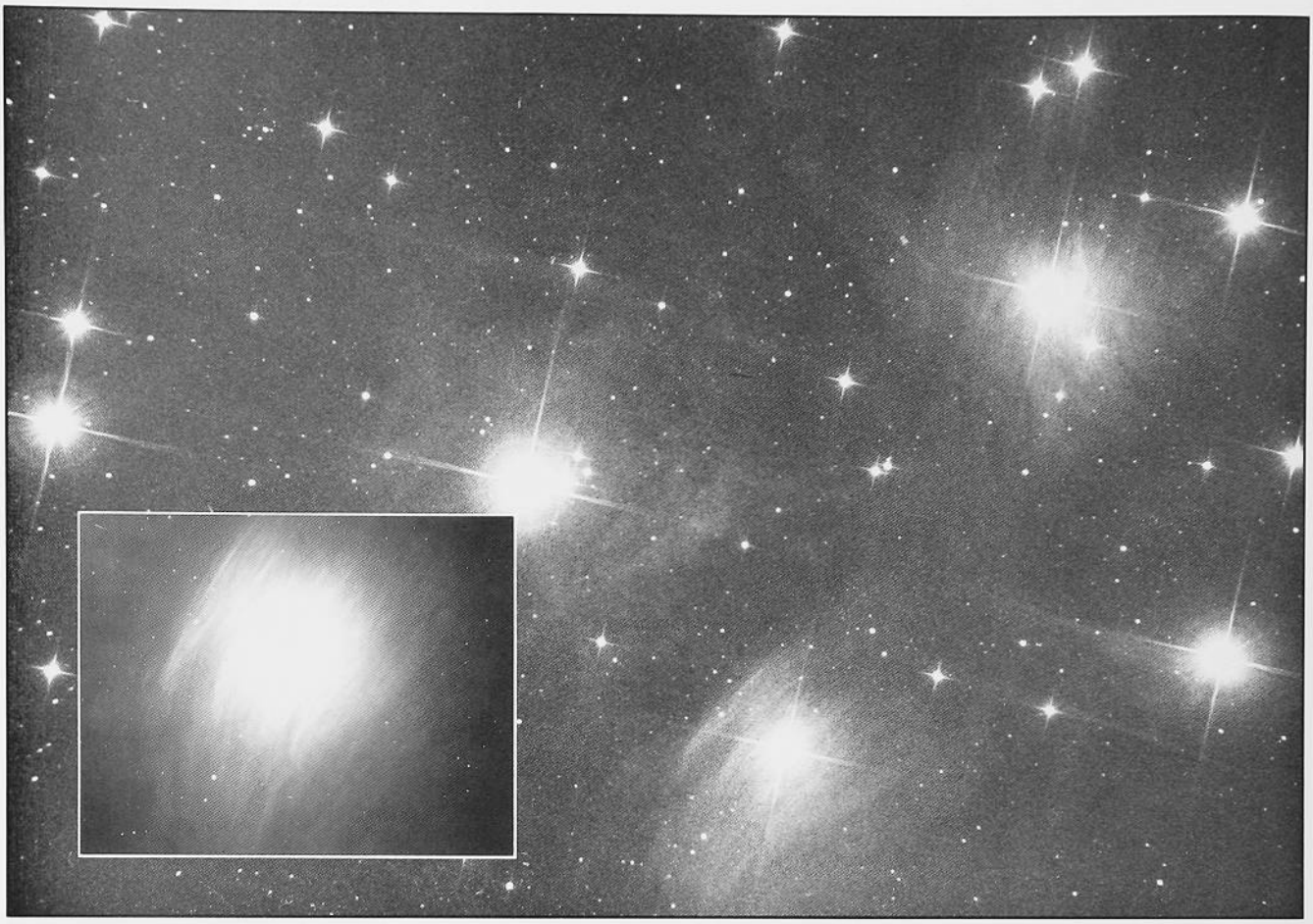
The Crab pulsar is the most thoroughly studied object of its type. During a supernova explosion the atoms that compose the doomed star are stripped of their protons and electrons, leaving only neutrons. The core of the star is crushed to about 20 to 30 kilometers across — no larger than the diameter of a big city. The density of a pulsar is almost inconceivable. Astronomers estimate that a thimbleful of its material would weigh 100 million tons on Earth.

As the star collapses, it spins wildly by intense gravity. The Crab pulsar continues to rotate thirty times a second, one of the fastest rates of any known pulsar. At each pass a sudden burst of energy from the pulsar sweeps over the Earth like a beacon from a distant lighthouse. The Crab continues to expand around the corpse of the progenitor star. Studies show that the Crab is growing at a rate of 0.2" per year, which, at a distance of 1.2 kiloparsecs, means a real velocity of 3.5 million kilometers per hour.

The Crab Nebula is detectable through 7x binoculars as a small, diffuse cloud about a degree northwest of Zeta Tauri. Its irregular oval shape may be suspected in 3- to 4-inch telescopes; it is clearly evident in 8-inch instruments. As aperture increases, mottled structure in the cloud begins to appear, although innu-



A great region of bright and dark nebulae lies near the Perseus-Taurus border. The dark cloud near the center of this photo is Barnard 4. Photo by E.E. Barnard.



Top: The Pleiades, M45, is one of the grandest sights any telescope can deliver. Preston Justis photo (10-inch f/6 reflector, 103a-O film, 45-minute exposure). Inset: Large scopes show nebulosity around the brightest Pleiads, like Merope. Kitt Peak National Observatory photo. Above: The planetary nebula NGC 1514 is a challenging object for small scopes. Martin C. Germano photo (8-inch f/10 SCT, hypered Tech Pan film, 120-minute exposure).

merable spiny projections which give rise to the "Crab" nickname are only visible in 16-inch or larger scopes.

Four degrees north of M1 lies a pair of little-noticed open clusters. Messier missed these clusters, as did the Herschels. Dreyer did not know of their existence when he compiled the *New General Catalogue* a century ago, and they were not recognized in the *Index Catalogue*. Both are listed in the Dolidze-Dzimselejsvili (DoDz) catalogue of clusters, a little-known listing. Yet for all their anonymity, both clusters may be seen in 6-inch instruments.

I spotted **Dolidze-Dzimselejsvili 4**, the larger of the two, for the first time through my 8-inch reflector last winter. This is a bright, scattered cluster of about two dozen magnitude 6 through 10 stars across 30'. Its ten brightest stars are easily seen in binoculars and finder scopes, which makes DoDz 4 simple to spot. About a degree northeast is **Dolidze-Dzimselejsvili 3**. I could make out thirteen magnitude 9 to 13 stars within the 14' diameter of this comparatively small group. The cluster's shape strongly reminded me of the constellation Cepheus.

Both DoDz 3 and DoDz 4 are positioned along the fringes of a huge, faint filamentary bubble of nebulosity known as **Simeis 147**. S147, first photographed in 1952 at the Crimean Astrophysical Observatory in Simeis, U.S.S.R., spans 3° in diameter. Its apparent similarity to the Veil Nebula in Cygnus, an ancient supernova remnant, suggests that S147 is all that remains of a star that exploded perhaps 50,000 years ago.

S147 is "traditionally" impossibly faint to see visually. Its soft, wispy nebulosity eludes detection. However, given today's fast optics, advanced eyepieces, and contrast-enhancing filters, S147 may shortly reveal itself. Readers fortunate enough to own mammoth reflectors might be able to spot the brightest parts. Try your luck on the next clear night and let us know how you did.

Planetary nebula **NGC 1514** lies between two 8th-magnitude stars north of Psi (ϕ) Tauri near the Perseus border. Many written accounts leave observers with the impression that NGC 1514 is a difficult object to see. When I first turned my 8-inch scope toward it a few years ago, I was pleasantly surprised. NGC 1514 was an easy find at 54x, even without a filter, from my less-than-dark backyard. The 9th-magnitude central star shone conspicuously. When I switched to 84x, the nebula's amorphous glow transformed into a well-defined, gray disk with a slight hint of mottling. Later investigation through my 13.1-inch scope showed the cloud's northern edge to be ever-so-slightly brighter than the rest. So if you are hesitant about NGC 1514 because of some notion about its visibility, wait no longer. The nebula may even be visible with 3- to 4-inch instruments on good nights.

Dolidze 14 is one of those objects that is plotted on a star atlas but you can never seem to find. This open cluster is shown on the *Uranometria 2000.0* just south of 41 Tauri, but when I aimed my telescope there a year ago, I found nothing. Averted vision, different eyepieces, and filters all failed to show anything. Just north of its position, however, lie nine faint stars interspersed with a trio of 7th-magnitude stars and the 5th-magnitude beacon 41 Tauri. Is this Do 14? Perhaps not, but it is an interesting asterism.

While you are looking at 41 Tauri, can you spot any hint of surrounding nebulosity? The following report from the *Webb Society Deep Sky Observer's Handbook*, Volume 2, page 101: "No nebula on Palomar charts. However, Selleck (S. Selleck of Santa Barbara, CA) reports a convincing observation with an 8-inch." What did S. Selleck see? Might it have been those nine faint stars I saw, or did he spot something else? Clearly more observations of this area are needed. As always *Deep Sky* welcomes your reports and findings for publication.

Taurus holds one of the most striking open clusters in the sky: M45, the **Pleiades**. The Pleiades cluster ranks as one of the greatest objects in the sky because it presents challenges to all observers whatever the equipment or experience. Most naked-eye observers can count four, five, or six stars arranged in the shape of a dipper. Slightly darker skies will reveal a seventh star, which permits the group to live up to its nickname the "Seven Sisters."

The naked-eye count increases even more under exceptionally dark skies. The late famed observer Leslie Peltier regularly noted from twelve to fourteen stars on moonless nights, while Walter Scott Houston glimpsed eighteen Pleiads from Tucson, Arizona, in 1935 (Scotty notes that from the same location today, light pollution has blotted out all but the five brightest). In all, twenty stars shine above the naked-eye limit, although many appear too close to neighboring stars to be resolved. Can any *DSM* readers equal or top Peltier and Houston's observational milestones?

The Pleiades are composed of at least one hundred stars scattered across a 110' diameter — nearly four times that of the Full Moon. This wide expanse makes it nearly impossible to fit the entire cluster into a single eyepiece field through many telescopes. Indeed, most amateurs agree that the best views of M45 come from rich-field telescopes and binoculars. I can recall the magnificent view I had of the Pleiades on a recent frigid but crystalline night. Across the field were myriad stellar diamonds. Looking carefully, I could glimpse soft, gossamer clouds of dust surrounding some of the brighter stars.

These gentle wisps are all that remains of a once-mammoth nebula from which the Pleiades cluster formed. Since the stars first "turned on" an estimated 78 million years ago, radiation pressure has caused the remaining clouds to slowly dissipate. With time all traces of nebulosity will vanish. For now, though, the nebulosity engulfing M45 remains a challenge for observers with small telescopes.

The brightest portion of nebulosity in the region is **NGC 1435**, enveloping Merope, the southeast star in the Pleiades' "bowl." Ernst Willhelm Tempel was the first to spot this comet-shaped cloud in October 1859. Viewing with a 4-inch refractor from Venice, Tempel described its tenuous nature as resembling "a breath on a mirror." If you don't see the nebula, place the star just out of the field of view. The chances of seeing the nebula will greatly improve.

NGC 1432 is an even fainter patch of light. Look for a small circular glow surrounding Maia, the northwest "bowl star," and extending northward. Once again, begin your search by placing the star just outside the field. By the way, many catalogues and atlases have chosen to label this quadruple star system. Maia's magnitude 2.9 primary is attended by a magnitude 8.0 "B" star found 117.2" away in p.a. 289°, the 8th magnitude "C" star 180.8" distant in p.a. 312°, and the magnitude 8.6 "D" star located 190.5" away in p.a. 295°. All four are detectable in 7x binoculars, and are striking through small telescopes.

John Herschel was first to catalogue the duality of **Taygeta** (19 Tauri). He listed it in his catalogue as h3251; modern measurements record the "A" and "B" stars as magnitude 4.4 and 8.1, respectively. The secondary star lies 68.9" northwest of the primary.

Less than two degrees northeast of the Pleiades lies a large interstellar cloud. Its two most prominent regions retain two separate entries in the *Index Catalogue* — **IC 353** and **IC 1995**. IC 353, the easternmost of the pair, surrounds a 6th-magnitude star, while IC 1995 is illuminated by a 5th-magnitude star. Both of these nebulae are extremely faint and have consistently eluded the roving eye of both my 8-inch and 13.1-inch telescopes, even under the best conditions. Can anyone visually spot either of these, or are they to remain only in the realm of the astrophotographer?

Taurus holds many pleasant hours of deep-sky traveling for amateur astronomers. The list of deep-sky objects it contains includes the Pleiades and Hyades clusters, the sky's best supernova remnant, faint planetaries like NGC 1514, and a slew of bright NGC clusters. On the next clear night try your hand at some new objects, and stop by some old friends as well.

Phil Harrington is an active observer who lives in Smithtown, New York.

Films, Filters, and the Facts of Life

by Rick Dilsizian

In the first three articles of this astrophotography series we have examined the different types of deep-sky photography: piggyback, prime focus, and Schmidt camera. Now let's evaluate the basic tools available to enhance the images of the sky you can produce.

The first choice astrophotographers must make is what film to use. The ideal film for deep-sky work should be fast, have a high degree of contrast, and be fine-grained. The film must be fast because most deep-sky objects astrophotographers will attempt to record are dim and require long exposure times. It must have high contrast in order to separate details in objects from the background sky. And the film must be fine-grained so that it can record small details and allow substantial enlargements.

Contrary to what you might believe, the best films are not necessarily the fastest. By "fast" I mean films that can record a unit amount of light in a relatively short amount of time. There are several reasons to balance film speed. First, fast films tend to be grainier than slow films. They do not provide high resolution as slower films do. These are general characteristics of faster films; it's a product of the way they're made.

However, the "fastest" films are not necessarily the fastest. This is no Earth-shaking statement. When exposed to light for long periods, films lose some sensitivity to light. They record light more slowly as a long exposure drags on. It's analogous to an out-of-shape runner — the first mile passes in five minutes; by the fifth mile the runner has slowed to a nine-minute-per-mile pace. By the eighth mile the runner is out of breath and gasping for air on the sidewalk.

Film works in basically the same way. Minutes into the exposure, the film, which may have started with an effective film speed of ISO 200, may have dropped its speed to ISO 20. Twenty minutes into the exposure that speed may be down to ISO 1 or even 0! In other words, the film has lost its ability to record light. Like the runner, the film has "collapsed" and any further exposure contributes nothing to the image. This failure of film to record at peak efficiency is called "reciprocity failure." Fast films generally suffer from the most severe reciprocity failure.

New films and filters have dramatically changed astrophotography during the past two years.

The runner has to train to get past the eighth mile — or maybe needs some Gatorade. But what provides an added boost for film? Perhaps the best boost is gas hypersensitization. Exposed to "forming gas," films can be sensitized in such a manner that they will perform near their rated speed for extended periods of time. By soaking film in a gas consisting of 8 percent hydrogen and 92 percent nitrogen at high temperatures for a long period of time, reciprocity failure can nearly be eliminated. For information on gas hypering see "Hypersensitizing, Parts 1 and 2" by Roger Sliva, April and May, 1981, ASTRONOMY.

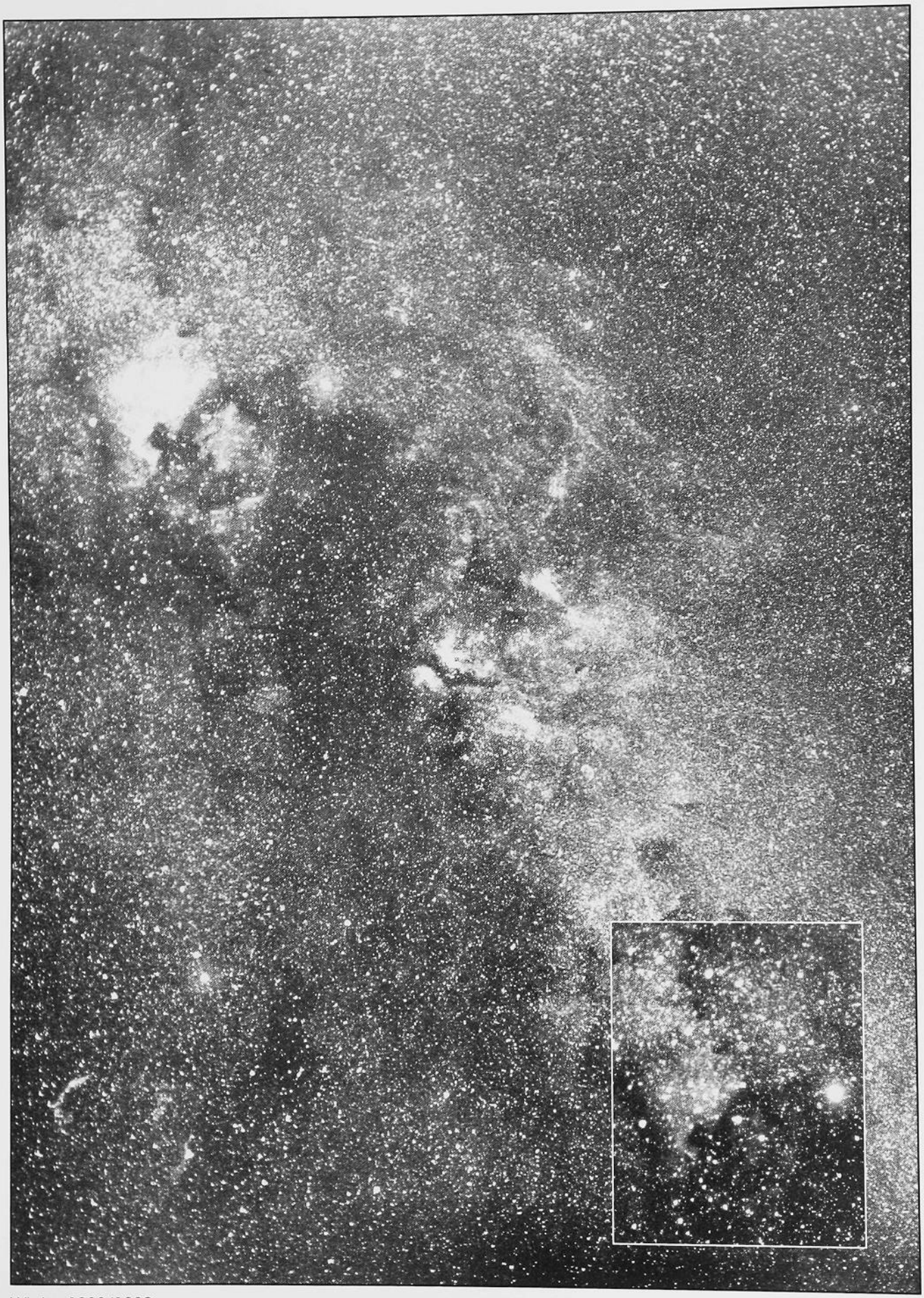
There are many types of films available for astronomical photography of deep-sky objects. Which black-and-white films work best? Kodak's Pan-X, Plus-X (TMAX 100), and Tri-X (TMAX 400) are black-and-white panachromatic films commonly available at department and drug stores. Pan-X is an ISO 32 film; it is slow but very fine grained. As slow as it is, Pan-X does not lend itself to deep-sky work. The same is true of Plus-X (TMAX 100), which is considerably faster but still not fast enough. Finally, there is Tri-X (TMAX 400), a fast film with a rating of ISO 400. This film displays good contrast and medium fine-grain characteristics. Because of its combination of speed, contrast, and grain, Tri-X is a good choice for exposure times up to several minutes.

Tri-X (TMAX 400) works well for fixed tripod photography. A 10-second exposure with a 50mm lens will show stars as points and record considerable detail. For exposure times of up to 5 minutes, this film is hard to beat. But what about past the 5-minute mark? Then you should look into Kodak Technical Pan 2415, a high-contrast, extremely fine-grained film that offers exceptional resolution when hypersensitized. This film is the best film for black-and-white astrophotography. Hypered Tech Pan can record dim details in objects over very long periods — an hour or more. Most of the black-and-white photos you see in the astronomy magazines were made with hypered Tech Pan.

There are many types of color film to choose from. There have been technical advances in color photography in the past five years, improving film grain and increasing film speed. Astronomical images can be captured with better quality in much shorter amounts of time. This is especially true when one considers two new print films that are "in vogue" for astrophotographers: Konica SRV 1600 and SRV 3200, superfast color negative films that record sky objects in a fraction of the exposure times used a few years ago. The quality of the negatives produced from these films is impressive.

Great improvements have also been made in slide films (Fujichrome 50, 100, 400, and 1600, as well as Ektachrome 100, 200, 400, and 800/1600). When hypered, most of these films perform well for astronomical photography. For Schmidt camera work, a slower film such as Ektachrome 100, Fujichrome 50, or Fujichrome 100 should be used because of the speed of the camera. For prime-focus work, a fast film should be used. Prime-focus work generally requires f/ratios between 5 and 10. Piggyback astrophotography can be done with either type of film.

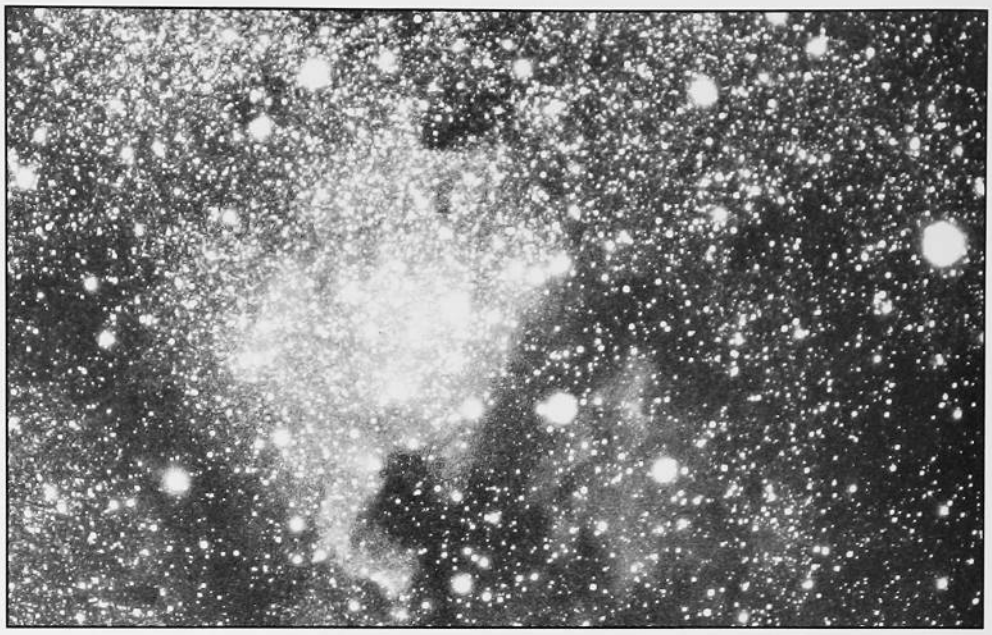
A 40-minute exposure of Cygnus demonstrates the benefit of using a Hydrogen-alpha filter. The photo, made with a 55mm f/2 lens and hypered Tech Pan, shows clean star images. Inset: A 5-minute, unfiltered exposure made with the same equipment has bloated star images. All photos by Rick Dilsizian.

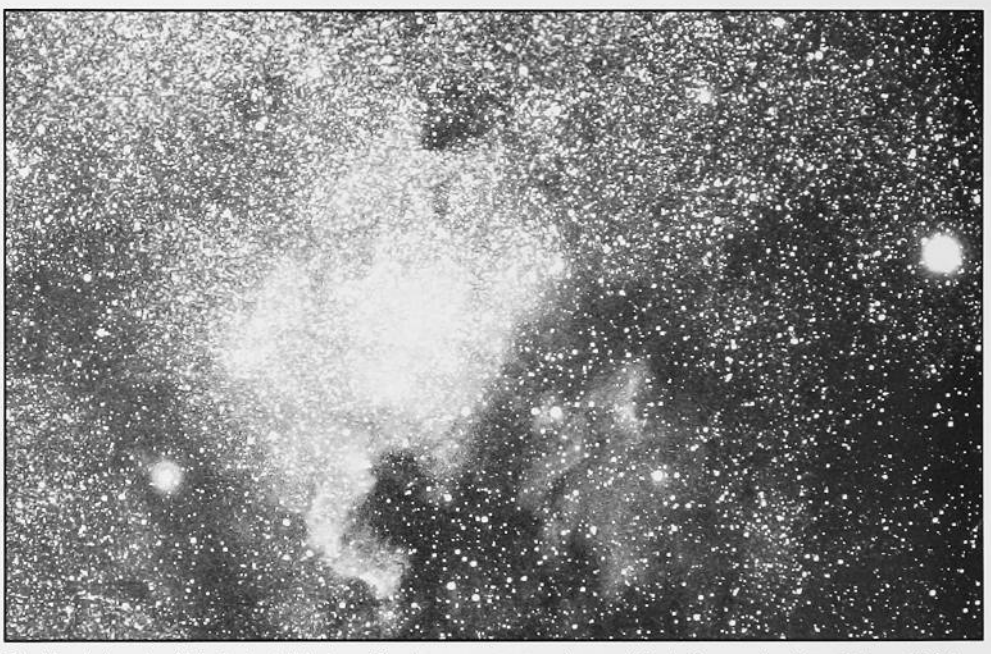


Most astrophotographers usually process color slide film as color negative film (in color negative chemistry) because the contrast is greater and it is far easier to control the color of the resulting print. But whether one processes negatives or slides as negatives does not matter — something that *does* matter is that a negative is produced. It is easy to adjust the sky background on a color negative to black when making a print or slide. Reciprocity failure on slide film processed as slide film affects each of the three colors differently, producing a greenish or reddish sky background. You certainly don't want to show that kind of astroslide to your friends!

Once you've decided what films to use, you can look into filters. Filters allow you to dramatically improve the quality of the image you will record on film. Remember that the choice of film affects the overall contrast and resolution of the the astrophoto. A further enhancement of the resolution and contrast of the photo can be produced by using filters. And we can also say that certain filters will actually improve the image formed by the optical system we're using!

The two main types of filters — Wratten gelatin filters and common 35mm glass filters — can both improve the image. But two high-tech filters produced by Lumicon are especially helpful. The Minus-Violet filter is designed to eliminate residual chromatic aberration in lenses — the unwanted property of different colors of light converging at different focal lengths near the film plane of the camera. Chromatic aberration means bloated, fuzzy star images that ruin the quality of astronomical photos. The Minus-Violet filter eliminates this problem by eliminating wavelengths of light below 4300 angstroms, a substantial portion of the near-ultraviolet component of the visible spectrum. And this results in a cleaner, crisper stellar image — a definite improvement in any astrophotographic image. Photographs of M42 in this article show this feature dramatically. The field around the Orion Nebula is shown in both photographs. Bloated star images detract from the original exposure.





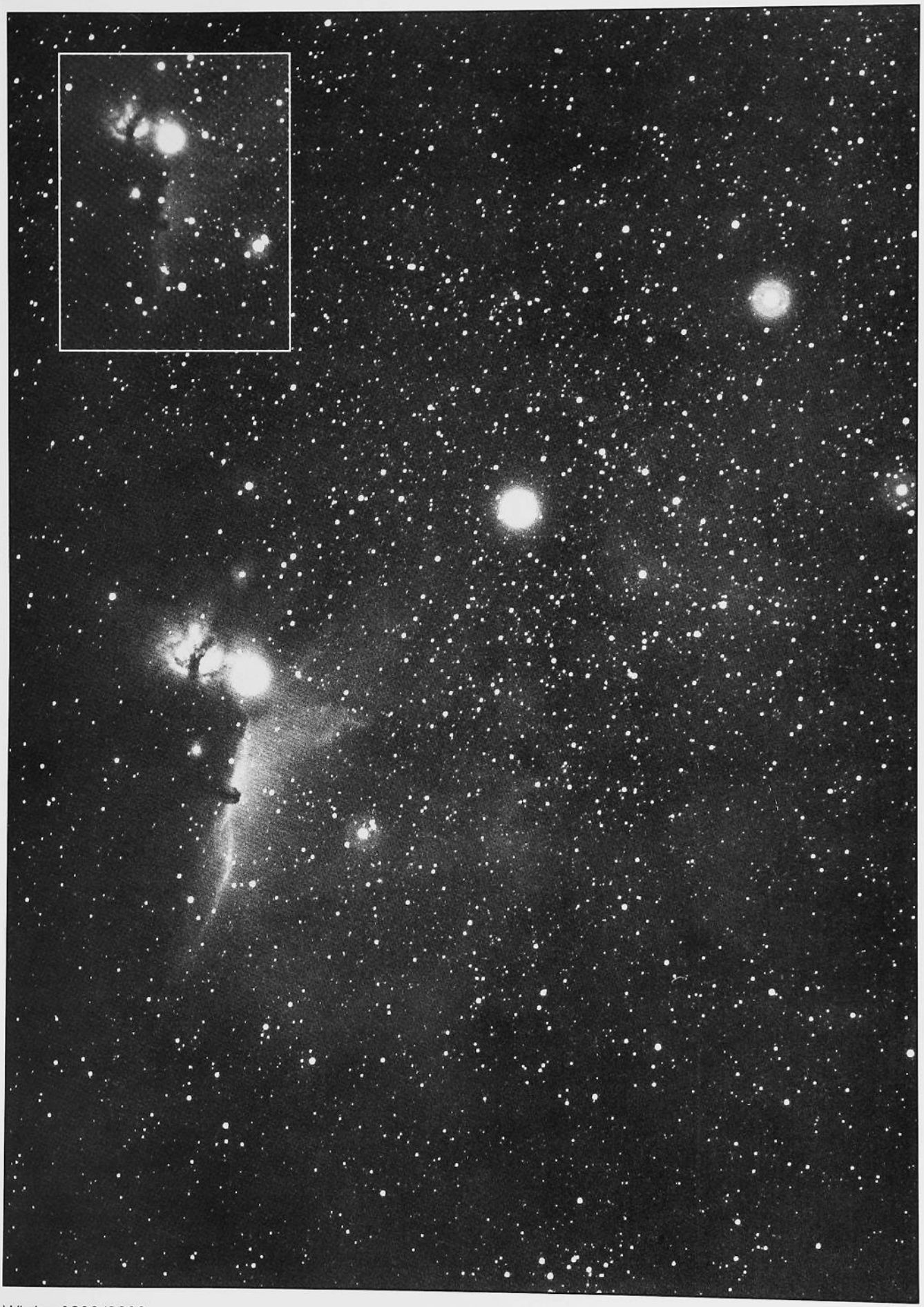
The North America Nebula is visible in a 10-minute exposure on hypered Tech Pan made with a 200mm f/2.8 lens. However, the image is marred by enlarged star images. Above: The same photo made with a Minus-Violet filter and exposure of 12 minutes yields a dramatic improvement. Opposite page: Orion's Horsehead region shows well in a Hydrogen-alpha shot; inset shows the same region photographed with a Minus-Violet filter.

The second exposure shows smaller, crisper images.

The second Lumicon filter is the Hα filter. This filter transmits only wavelengths of light above 6300 angstroms. Anything below this wavelength is absorbed by the filter. Because most manmade light pollution lies within this region of absorption, the Hα filter eliminates artificial light pollution. The filter transmits light from the ionized hydrogen line at 6563 angstroms, the principal source of energy from emission nebulae. Thus the Hα filter works well on objects like the Horsehead Nebula, the North America Nebula, and the California Nebula. The net effect of its transmission characteristics is contrast gain for these types of deep-sky objects — even from urban and suburban areas. The only problem associated with the Hα filter concerns exposure time: they run four to five times longer with the filter to obtain the same image density as an unfiltered exposure.

The Horsehead Nebula photos illustrate the point. Notice that the Horsehead is barely visible in the exposure taken with the Minus-Violet filter. Though this filter produces clean star images, it does nothing to increase the contrast of the nebula itself. However, the Hα photo of the Horsehead is much improved. The Minus-Violet filtered exposure was 11 minutes; the Hα exposure was 55 minutes — exactly five times longer.

Astrophotographers are faced with a dilemma: image quality versus long exposures. The only consolation is the availability of faster lenses that will decrease exposure time. The



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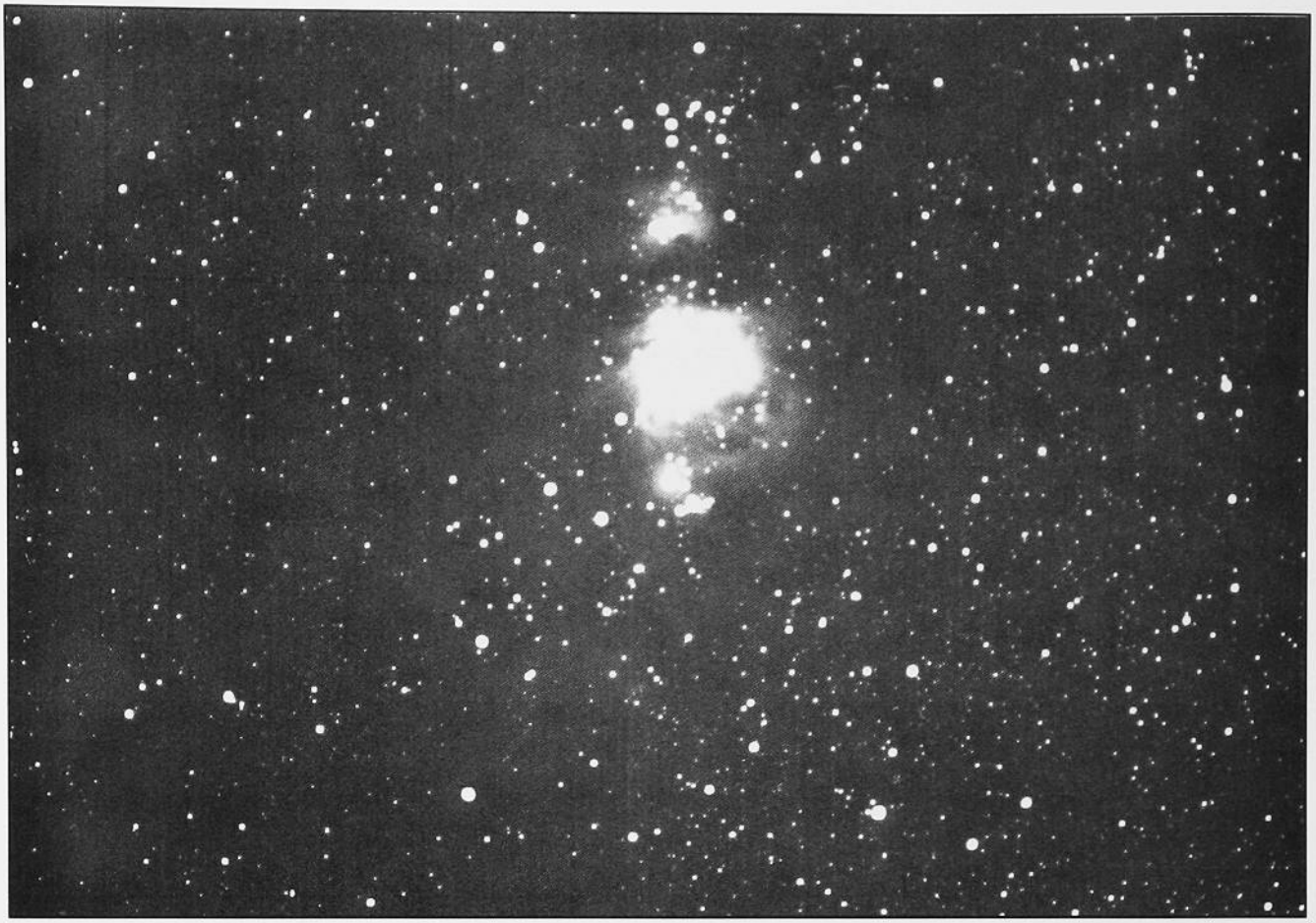
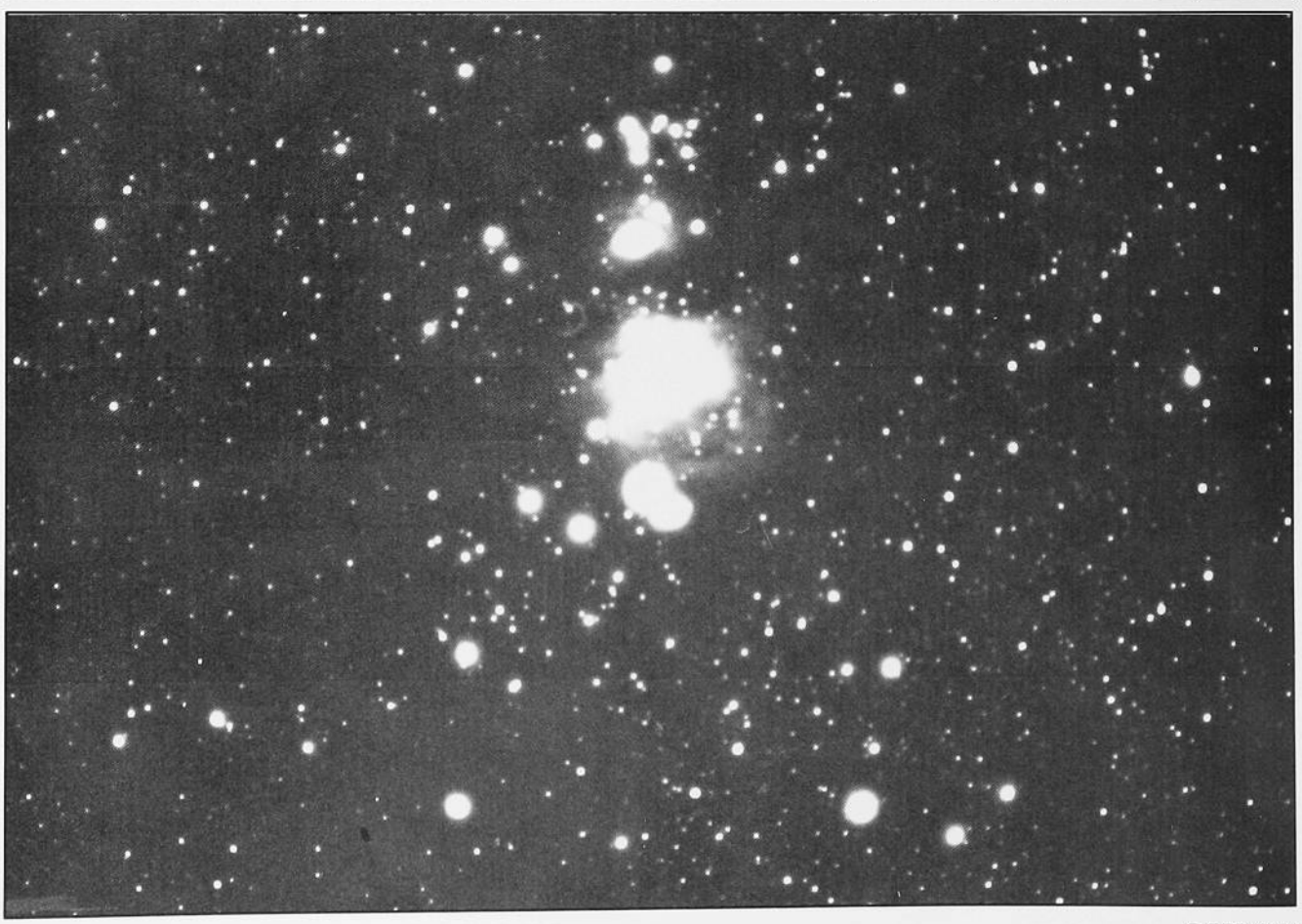




Above: Orion recorded on unhypered Tech Pan shows clean images and a lack of background grain. Inset: The same shot using TMAX 400 film yields a gritty, grainy sky background. Opposite page, top: Orion's sword photographed with a Minus Violet filter reveals a fine portrait of the nebula. Opposite page, bottom: An unfiltered view of the same region looks fuzzy, bloated, and unsatisfying.

Cygnus Milky Way photos bear this out. One was taken with a 50mm "normal" lens — a 5-minute exposure at f/2. The second photo shows the same picture with an Hα filter added. The resulting 20-minute exposure shows an increase in the resolution and contrast.

Another problem with these filters is that the lens must be refocused slightly (it will not focus exactly at infinity) because another optical component has been added to the system. For the Hα filter, the lens should be set at 60 percent of the distance between infrared focus (the red dot on the distance scale of your lens) and normal infinity.

By choosing the right film and filter you can optimize the quality of your images. Filters can make astrophotography a pleasure rather than a frustration — even from areas saturated with light pollution. All it takes is some knowledge and patience to practice this grand combination of science and art.

Rick Dilsizian lives in Mahopac, New York.

There's a problem running rampant among Newtonians: stray light. This disease has flourished undiagnosed in epidemic proportions for decades because hardly anybody has ever seen a well-baffled Newtonian. To be frank, this baffling affliction is not a killer. It's one of those chronic maladies that degrades telescope performance without ever becoming acute.

Yet stray light is an easy ailment to cure — once you recognize it and take action. It only takes an hour or two of your time to look and think, cut a few baffles of thin cardboard, place a couple dabs of black paint, and glue a little strip of velveteen inside the focuser.

In this article, I'm going to give you some background on how light bounces around inside a Newtonian, differentiate between the baffling needs of astrophotographers and the slightly less critical baffling needs of visual observers, tell you a bit about the well-baffled Newtonian that opened my eyes to the marvels of baffling, and conclude with some hints that will help you achieve a blacker, more velvety sky background from your own Newtonian.

Baffling for Astrophotography

Every photon of light that reaches the focal plane of a photographic telescope blackens film; film really doesn't care whether a particular photon came from the nebula you're trying to record or a neighbor's yard light. You do.

The biggest problem the Newtonian has is that light entering the open front end can easily reach the film. If the focuser is near the open end, light from the end of the tube may enter the focuser tube directly. It may also reflect off the bottom end of the focuser and toward the focal plane.

The simplest cure is a long tube — a tube extending at least twice the mirror's diameter beyond the focuser. The best cure is a baffled snout — section of oversized tube extending at least twice the mirror's diameter beyond the focuser. Within the snout are baffles — rings of thin blackened cardboard — that prevent light from traveling down the tube. From the mirror end of the tube, only the dark backs of the baffles are visible.

If you don't fix stray light, stray light will fix you.

Light from the open end also illuminates the diagonal mirror, its supports, and the upper walls of the tube, and that light also reaches the film. An extended tube will reduce the intensity of this light but usually not enough. To help eliminate this problem, blacken everything in the light path as completely as possible, either with flat-black paint or with a black covering such as flock paper or black velveteen.

Flock paper and velveteen are both black because they're covered with millions of shiny little black hairs. Light strikes the hairs and bounces deeper and deeper into their midst until it's "trapped." These materials are blacker than the blackest paints, and they make a great black coating for any surface where their roughly 1/16-inch thickness doesn't matter.

Light may also pour around the mirror cell. Even if the ground were completely dark, stray light should never have any path to the film. A mirror cell a la Build Your Own Telescope ventilates the tube without letting in much light, but a simple baffle behind the cell will block the direct line of sight.

The wall of a Newtonian astrograph's tube is seldom responsible for much stray light because the diagonal mirror acts like a stop to block the light reflected from it. Even if a fair amount of light bounces from the tube surface and strikes the mirror, it never reaches the film plane because the diagonal is too small to catch it. The tube should be black, but it's usually not worth fanatical measures.

The focuser and its tube are often strongly illuminated by off-axis light from the primary mirror. Reflections of bright stars outside the field are fairly common in Newtonian astrophotos, as are fields in which the edge of field is brighter than the center, because of this light. It may be necessary to baffle the end of the focuser tube to block this, and it's always worthwhile to blacken the focuser and camera adaptor tubes with flock paper or velveteen.

Baffling for Eyeball Observers

Because the light coming from the sources in the telescope will not reach the retina in your eye if the sources do not lie within a 7-millimeter circle behind the eyepiece, baffling for visual observing is far less critical than it is for photography. Concentrate on eliminating sources that lie within a small angular distance of the primary mirror — the diagonal, the mirror cell, the tube opposite the focuser, the bottom end of the tube, and the upper end of the tube.

Visual observers must not forget another important link in the optical system: transferring light from the eyepiece to the eye. Observers tend to ignore this step because, as they move their heads around, the patterns of scattered light change, and it's easy to minimize them. For the best results you need to eliminate these patterns.

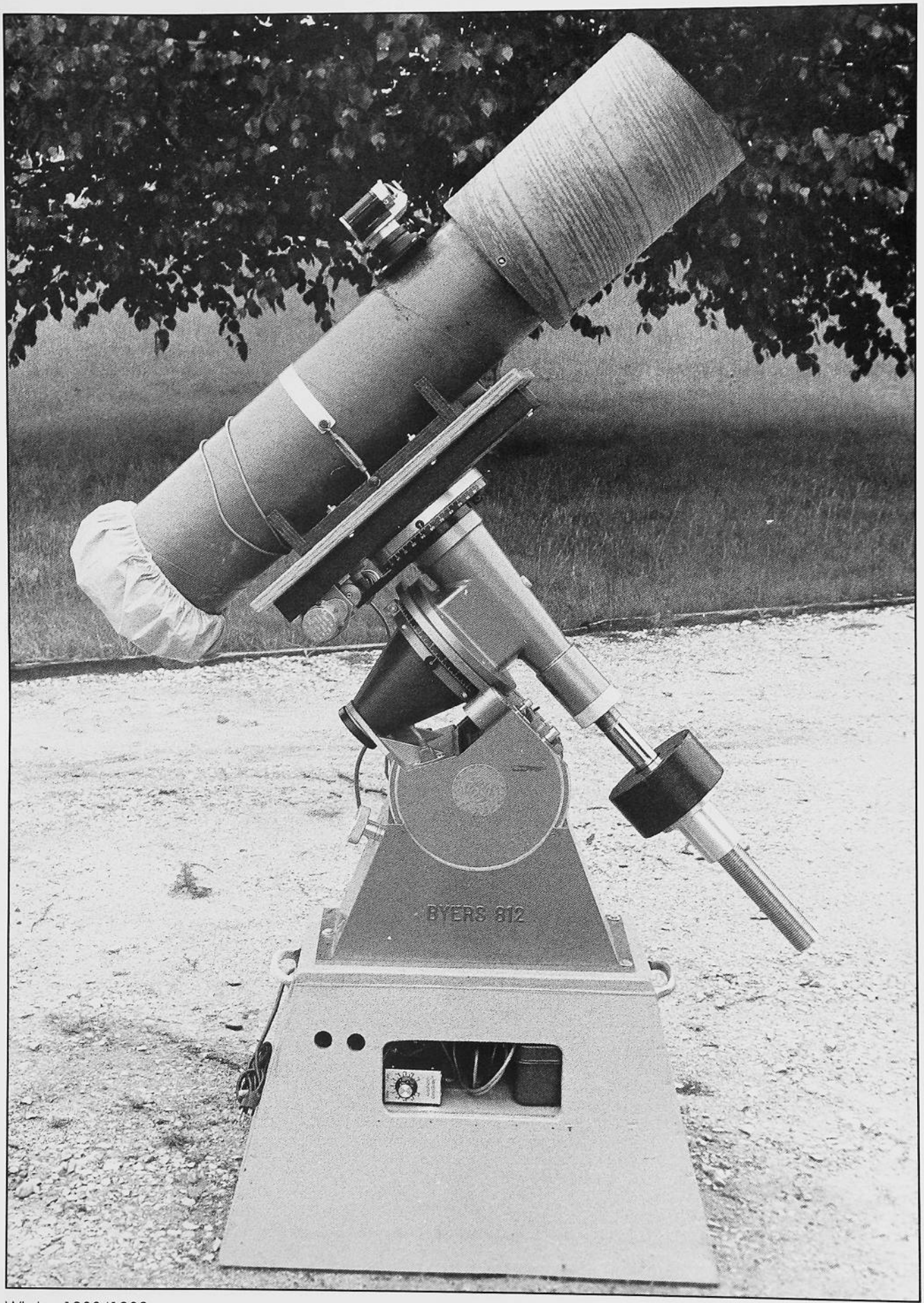
The most obvious problem is that light from the sky and any lights near you observing site reflect from the eyepiece lens and the sides of the eyepiece and into your eye. Many observers cup a hand around their eye and the eyepiece to reduce this annoying stray light.

But suppose you're observing with a light pollution filter placed in the eyepiece. Skylight reflects from the convex surface of your eyeball into the eyepiece, which collimates it into a parallel beam. It strikes the filter and comes back through the eyepiece, illuminating the entire field with a more-or-less uniform glow. If there are any street lights around, you'll get fleeting "ghosts" in the field — light that's bounced off your eye and into the eyepiece!

You can cure both problems by putting a black cloth over your head and the eyepiece. Tuck the cloth in so you can't see any light except what comes through the eyepiece. The black cloth trick accomplishes three things: it eliminates direct stray light, it eliminates light reflected from the eyepiece lens, and it eliminates light reflected from the eye itself. In the relative darkness under the cloth cover, your pupil expands to its maximum and in the total absence of glare your dark adaptation is improved.

The Well-Baffled Newtonian Astrograph

I built my fully baffled Newtonian as a general-purpose photographic telescope for Build Your Own Telescope. (It was later dropped from the book.) My goal was to build a telephoto "lens" capable of jobs from shooting quick snaps of close planetary conjunctions to hour-long exposures of deep-sky objects or terrestrial football photography. I chose a 6-inch f/5 Newtonian for its low-cost optics and baffled it fully, so it



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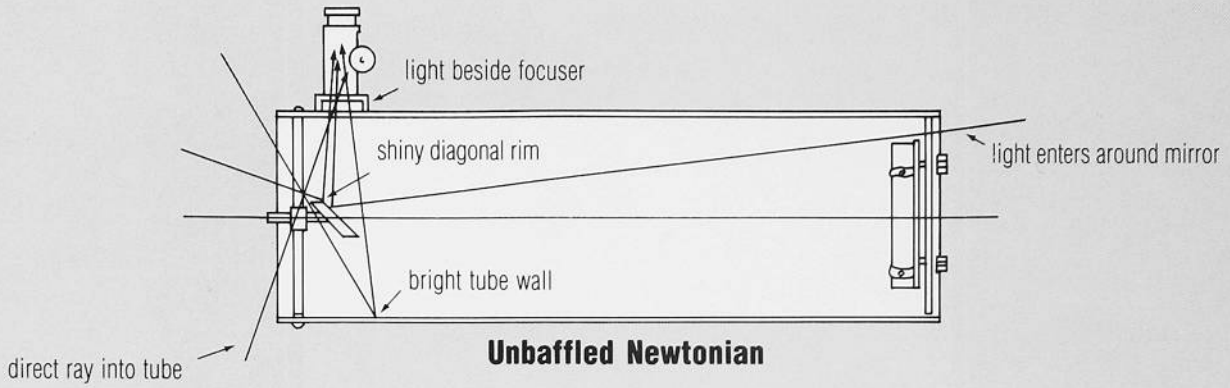
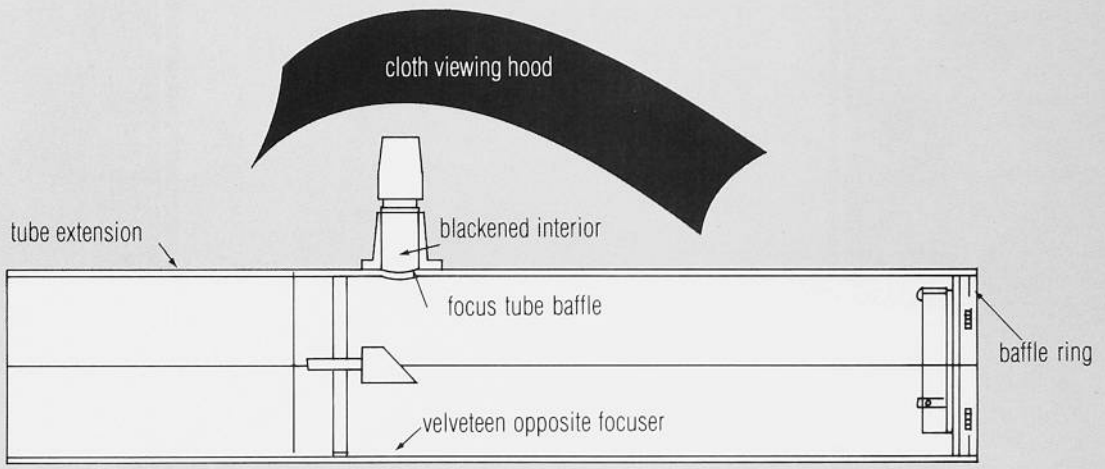
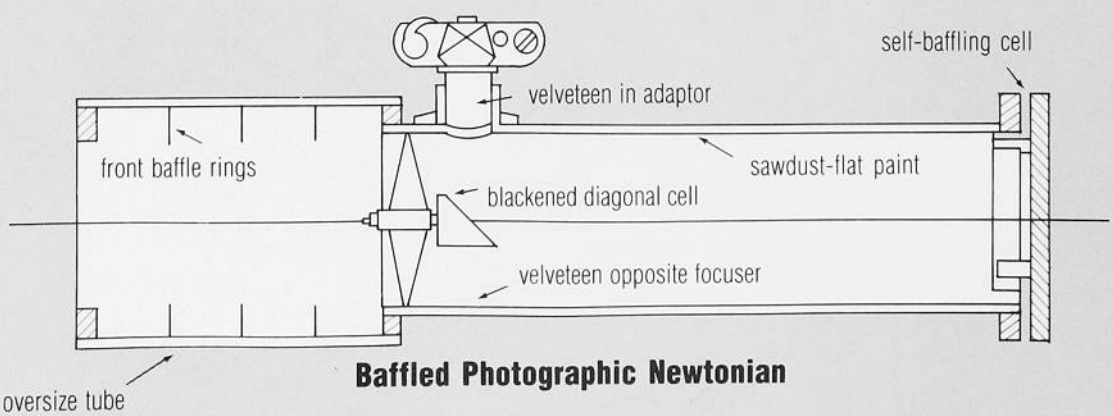
WELL-BAFFLED NEWTONIANS FIGHT LIGHT



Unbaffled Newtonian



Baffled Visual Newtonian



Baffled Photographic Newtonian

would be as light-proof as any standard camera lens.

The accompanying photograph shows the salient design features of this telescope. It has a 12-inch snout with four 1-inch-deep baffle rings that very effectively block off-axis light. It has a mirror cell that's closed in back, so no light creeps past the mirror. I blackened the secondary mirror cell, and the tube opposite the focuser has black velveteen glued to it. The focuser tube is in line with velveteen to prevent low-angle reflections from off-axis light from the mirror, and a small baffle at the base of the focus tube reduces the amount of light the velveteen must absorb.

Photographic tests have shown that it really works. I have shot long-exposure star trail photos under brilliant street lamps without fogging, and long-exposure photos on Konica SRV 3200 have not been ruined even when I've accidentally turned on the observatory lights. Photos shot with the astrograph show it has an evenly illuminated field, with none of the vignetting, ghosting, and stray-light hot spots that often characterizes Newtonians.

Most surprising to me —- because I didn't build the telescope for the purpose — has been the visual performance. With the aid of a UHC filter, a black cloth thrown over my head, and a 20mm eyepiece to give what I consider the optimum deep-sky exit pupil of 4mm, I've observed the North America Nebula, the Pelican Nebula, the Helix, the nebulosities around Gamma Cygni, and the California Nebula.

Getting Everybody Baffled

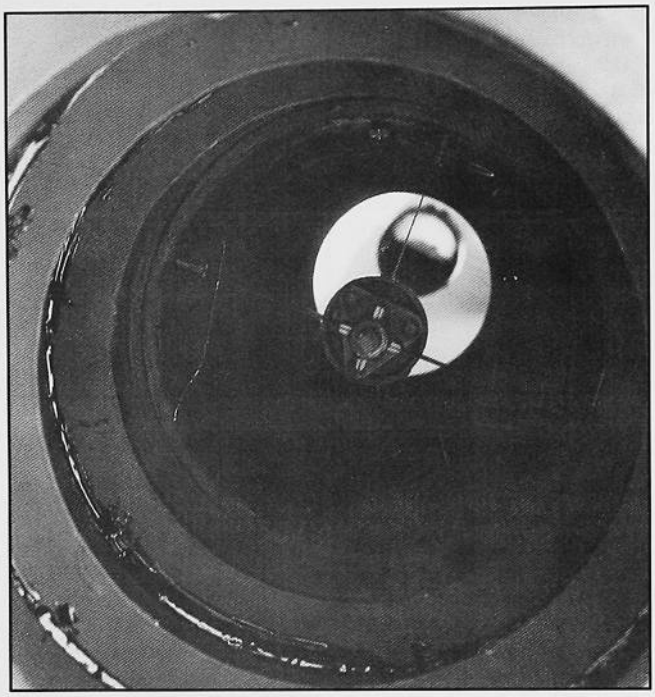
You're the one who has to diagnose, decide on a course of treatment, and cure your telescope's baffling problems — if indeed it even has any.

Here's how to diagnose. Set up the telescope (on its mounting so you can point it easily) in a well-lit room, preferably a room with white or light-colored walls, with the telescope. Tape a circle made of black construction paper about twice the aperture of your telescope to the wall about six feet up, and point the telescope at it. Now, remove the eyepiece, and look into the focuser tube. The mirror should look dark to you because it's forming an image of the black spot on the wall. What else do you see?

• Does the mirror cell let a ring of light from behind the tube shine past it? If it does, cut a ring from cardboard, spray it with quick-drying flat-black enamel, and spring it into the bottom end of the tube. The outside diameter of the ring should be equal to the inside diameter of the tube and its inside diameter equal to the diameter of the mirror. Don't press the ring close against the mirror cell or mirror because you want good air flow down the tube and around the mirror.

• Is the tube wall opposite the focuser brightly lit? If it is, make a tube extension twice the mirror diameter in length from light cardboard or any other material you feel is appropriate as long as it's blackened. (If you're a fanatic, make a baffled snout.) Slip the tube extension over the front of the tube and tape it in place. The opposite tube wall shouldn't be as bright as it was before.

• Does the telescope have an open tube? If you can see past the diagonal to the walls of the room, make a baffle for the opposite side of the telescope that blocks the view. Be sure the baffle is big enough so you cannot see past the tube from any spot in the focal plane. The baffle can made of any light flexible material and can be removable.



In a photographic Newtonian, baffles prevent stray light from reaching the focal plane and fogging the film. Looking into the tube, note the illuminated front sides of the baffles. Their back sides – the sides the mirror sees – are dark. The baffles are made from black cardboard. Photo by Richard Berry.

Also consider making a cloth sleeve to enclose the entire light path. You might not use it all the time, but for critical observations the extra few tenths of magnitude could well be worth it. Dark double-knit cloth comes in stretchy tubes, or you can sew a tube from any dark cloth, and put buttons or Velcro fasteners down the side to close it.

• Is the diagonal mirror or its cell bright? If there are unpainted rough glass aluminized surfaces, glints from unpainted metal parts, or specular reflections from shiny paint, paint them with flat-black paint. Use a small brush and don't slop paint everywhere — just on the glare spots. There's a limit to how much light black paint can absorb, and some paints are better than others.

I prefer flat-black Rustoleum with as much fine sawdust as the paint can carry mixed in with it. Make it in batches of a half-pint at a time, and apply with a brush under a quarter-inch in diameter.

• Can you see reflections in the focuser tube? Depending on whether the tube is long or short and how much of its length is occupied by eyepieces, try one or both the following fixes.

Insert a baffle ring from blackened cardboard that fits just inside the lower end of the focus tube. Its inside diameter should be between 1/4 and 1/2 an inch less than the tube diameter of the focuser. Don't allow this baffle to vignette the light from the mirror — make it just wide enough to cut reflections in the tube.

Glue flock paper or black velveteen cloth to the inside of the focuser tube. Duco glue holds well, yet you can strip it out if you decide you don't want it there later. Your longest eyepiece tube sets the limit of how far up the tube the antiglare material should come.

By now you should be seeing a pretty black scene when you look into the focuser tube. What's still bright? If the tube opposite the focuser is still bright, cover it with flock paper or velveteen. If the inside of the tube is shiny, consider repainting the entire inside tube wall with Rustoleum and sawdust or applying flock paper.

One final reminder: The gap between your eye and the eyepiece is as critical as any baffles inside the telescope. Use the black cloth trick especially when you're observing with light-pollution filters. It's worth at least half a magnitude even at dark sites and indispensable from bright sites.

On the construction side, keep looking for glare and remedying it until you reach a limit that's practical for you. The first couple fixes you make will probably kill off 80 percent of the glare — so you'll soon encounter the law of diminishing returns. Do it and you'll enjoy darker skies and better deep-sky performance from your telescope.

1027 North 7th Street
Milwaukee, WI 53233

Deep Sky Reports
Why Observe Open Clusters?
by Tom Matty

I started observing open clusters about two years ago. At the time I was just beginning to sketch deep-sky objects and I felt that a loose conglomeration of stars would be the easiest type of deep-sky object to draw. I quickly became hooked on observing these beautiful collections of stars and even today I'm fascinated by the individuality each open cluster.

Why observe open clusters? With little magnification they can be resolved into individual stars, so they are much less affected by light pollution or haze than nebulous objects. This means that on a night when I don't feel like leaving my light-polluted backyard, I can do some worthwhile observing by looking at bright star clusters.

Furthermore, open clusters are much simpler to draw than any other class of object, because no shading or subtle contrasts are involved. Just accurately positioned pencil dots, their sizes showing magnitudes, produce a star cluster's portrait. Because it teaches you to position stars accurately, drawing open clusters develops drawing abilities for more difficult sketches and sharpens your eye.

When preparing to view any deep-sky object, I first do a little research so I have some idea of what I'm looking for. My main reference for all deep-sky objects is the *Sky Catalogue 2000.0*, Vol. 2 (which contains all of the clusters found on the *Uranometria*). However, for faint open clusters I consult the *Gosta Lynga Catalogue*, a definitive work indeed.

My list of pertinent information for each cluster includes:

1. Trumpler type -- for a rough idea of the number of stars, range in brightness of cluster members, and how well the group stands out from its background (see the box for more information).
2. Number of stars.
3. Magnitude of the brightest star.
4. Angular size of the cluster.

I do not include total magnitudes of the clusters because this number equals the light of all members compressed into a point source, which doesn't tell me a lot about how the cluster will look. In fact, total magnitudes for open clusters could make you believe a cluster is brighter than it actually appears.

The total number of stars in a cluster is important. If you are looking for a group of seventy stars, you won't mistake a small asterism of six stars for the cluster. Likewise, you must search carefully for a cluster of fifteen stars in the Cygnus region or you might mistake a clump of background stars for the object.

A good example of this is **IC 2157** (Trumpler III 2p) in Gemini, a small, striking cluster of only twenty stars, six of which are arranged in a small Orionlike asterism. Someone who has no idea of the number of stars in a cluster and was accustomed to bright, rich Messier clusters would likely pass right over IC 2157, mistaking it for a random field asterism.

The magnitude of a cluster's brightest star also plays a big factor in the "observability" of a cluster. Nothing is more important than the the Trumpler class, however. The number 1, 2, or 3 in the Trumpler classification system tells how much star brightnesses vary in the cluster. Knowing the magnitude of the brightest star and the range, you can have an idea of how bright the cluster members will be. A good example of this is **NGC 6802** (III 1 m) in Vulpecula.

Easily found near the "Coathanger," this cluster is listed with an integrated magnitude of 8.8. However, the brightest star in this cluster glows at magnitude 12.9. With a Trumpler value of 1 (a small range in brightness), this is a tough object. Thus, most of the stars are dimly visible at magnitude 13. Because this is near the limit of an

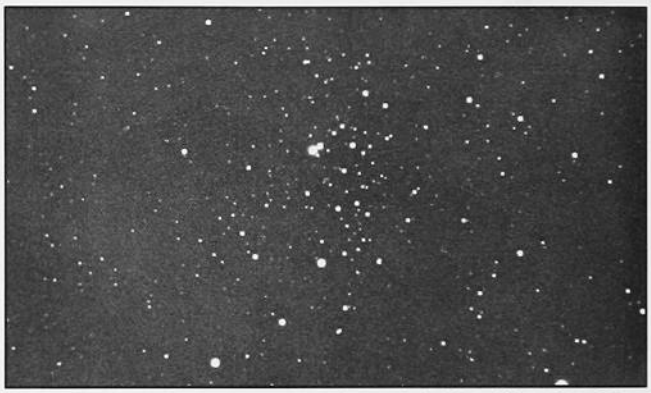
The Trumpler Classification

Concentration:
I - Detached, strong concentration towards the center.
II - Detached, weak concentration towards the center.
III - Detached, no concentration towards the center.
IV - Not well detached from the surrounding starfield.

Range in Brightness:
1 - Small range in brightness.
2 - Moderate range in brightness.
3 - Large range in brightness.

Richness:
p - Poor, less than 50 stars.
m - Moderately rich, 50 to 100 stars.
r - Rich, more than 100 stars.

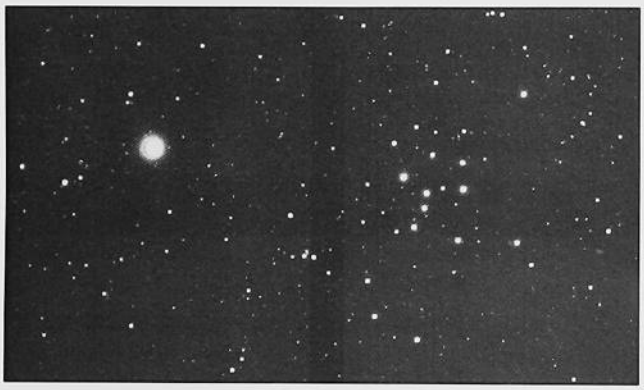
A couple of examples: as one might expect, Messier 11, the Wild Duck Cluster, type I 2 r is a rather lovely cluster. Although M35, at III 2 m is moderately rich, its lack of concentration towards the center and moderate range in brightnesses of stars can permit one to sweep right over it at medium powers. The most difficult type of cluster to find is a IV 3 p, which would represent a spattering of stars on an almost similar background.



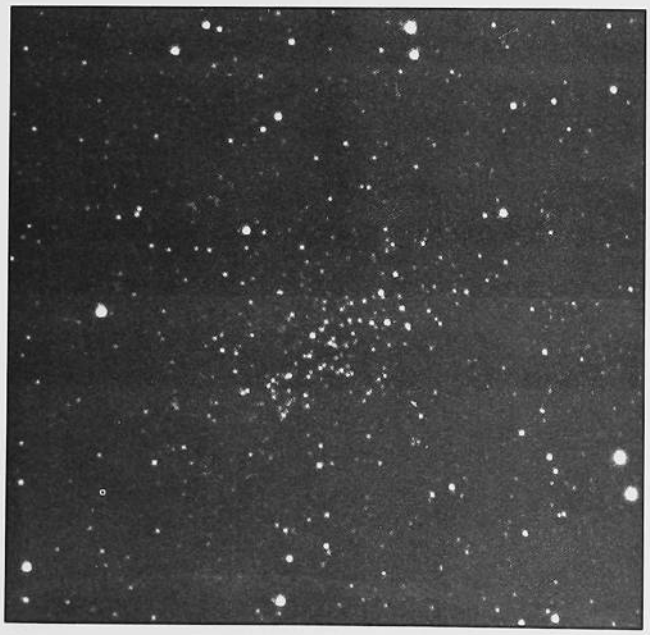
NGC 957. Martin C. Germano photo (8-inch f/10 SCT, 103a-F film, 35-minute exposure).

M11, Kim Zussman photo (11-inch f/10 SCT, hypered Tech Pan film, 15-minute exposure).

M35 and NGC 2158. Jack Marling photo (200mm f/2.8 lens, hypered Tech Pan film, 40-minute exposure).



IC 4665. Janos Papp photo (300mm lens, ISO 400 film, 21-minute exposure).



NGC 6802. Martin C. Germano photo (8-inch f/10 SCT, 103a-F film, 60-minute exposure).

8-inch telescope under reasonably good conditions, you could expect to see something akin to a milky nebulosity. If you work hard at it, you can pick out three to five individual stars.

Those of you with larger scopes will enjoy observing this extremely beautiful cluster of fifty stars. The group shows a compact "M" shape like McDonald's golden arches. With my 10-inch scope I only saw that the group had a hump.

Size must also be combined with the other three statistics (Trumpler type, number, and magnitudes of stars) to get an idea of what to look for. Use a magnification that yields a field of view slightly larger than the size of the cluster and hopefully sufficient to resolve the inner region. Naglers are perfect for this sort of work.

You can pass through a large, unconcentrated cluster (e.g. **IC 4665**, II 2 p, in Ophiuchus, or **NGC 6885**, III 2p, in Vulpecula) several times when you're using medium powers because you won't notice the increase in star density in a small field of view. IC 4665 is easily found in binoculars or a finder scope. This is particularly important in Milky Way fields where large numbers of stars fill the field. Often, quick passes back and forth over a weakly detached cluster (type IV) will show the slight drop-off better than methodical searching.

Usually I do not advise looking at pictures or reading about objects before observing them. This biases observations and only heightens the imagination. However, for small, poor clusters in rich regions it is essential to have some idea of what the cluster looks like before trying to observe it. Otherwise it is easy to mistake almost anything for the cluster, particularly small asterisms of bright stars in the Milky Way.

In observing and drawing clusters I follow several steps. When I find the cluster, I simply take in the view for a while. I then look more closely, changing magnifications, checking for colored or double stars. I also guess the Trumpler type and estimate the number of stars. In addition, I check the field with an UHC or OIII filter to look for nebulosity.

You must be careful when using filters because unresolved cluster members may appear as a nebulous patch. Include any nebulosity you see in your sketch and comment on its appearance with and without filters. This will give you an indication about its nature. Later you can verify your observation with the *Nekel-Vehrenberg* or *Palomar Sky Survey* atlases.

These steps can turn up a great amount of detail you might miss at first glance, which increases your sense of accomplishment. Many clusters contain double stars; a good example is Trumpler 1. The use of high magnifications, large apertures, and especially patient and careful observing brings out great detail. Colored stars are also common. For example, there are at least seven red stars in and around the Double Cluster in Perseus.

When you're ready to make a sketch, keep in mind that the star positions matter the most. I usually center an obvious asterism or bright star in the eyepiece. By carefully connecting asterisms and geometric shapes I work my way out to the edges. Others sketch from the edge inward -- it's a matter of personal taste. Nebulosity and unresolved stars can then be added with the use of a soft pencil and some careful smudging.

Another nice thing I have discovered about clusters is that it is easy to move away from the commonly observed NGC and IC objects to enter the realm of the lesser-known King, Dolidze, Ruprecht, and Trumpler clusters. Unlike the esoteric objects of the other classes, these faint open clusters are not difficult to identify. An outstanding example of this is **Dolidze 11** in Cygnus.

For someone with a more scientific bent, clusters often contain variable or flare stars that can be observed with photographic blinking techniques.

Open clusters are too often ignored as deep-sky objects, but they offer a great deal to observers of all experience levels. You may want to appreciate the Messiers or challenge yourself with seldom observed, more difficult objects. Regardless of what you enjoy about observing, clusters will delight and surprise you.

Deep Sky Reports

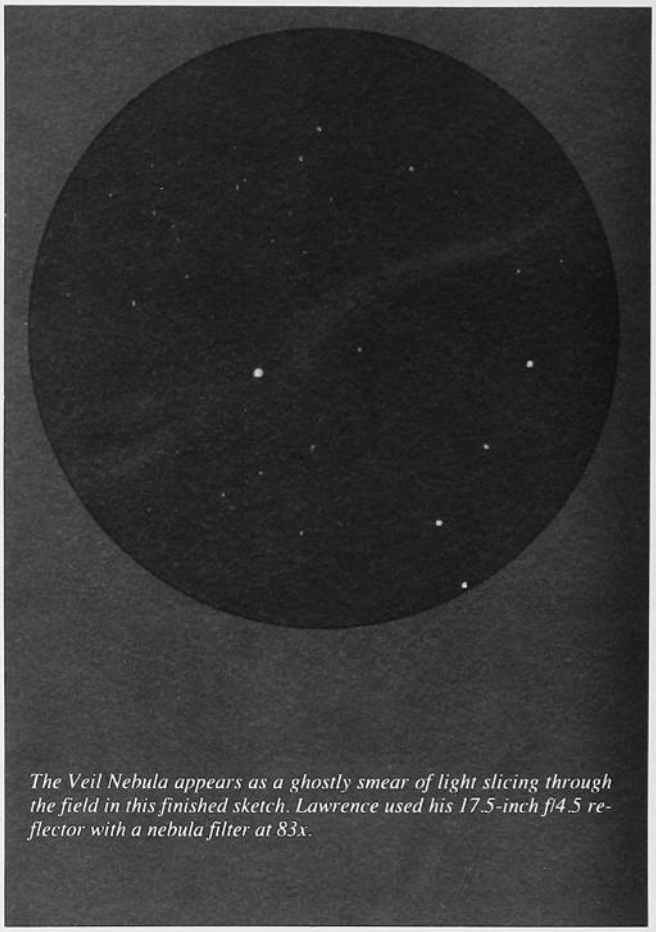
Photograph Your Sketches the Easy Way

by James W. Lawrence

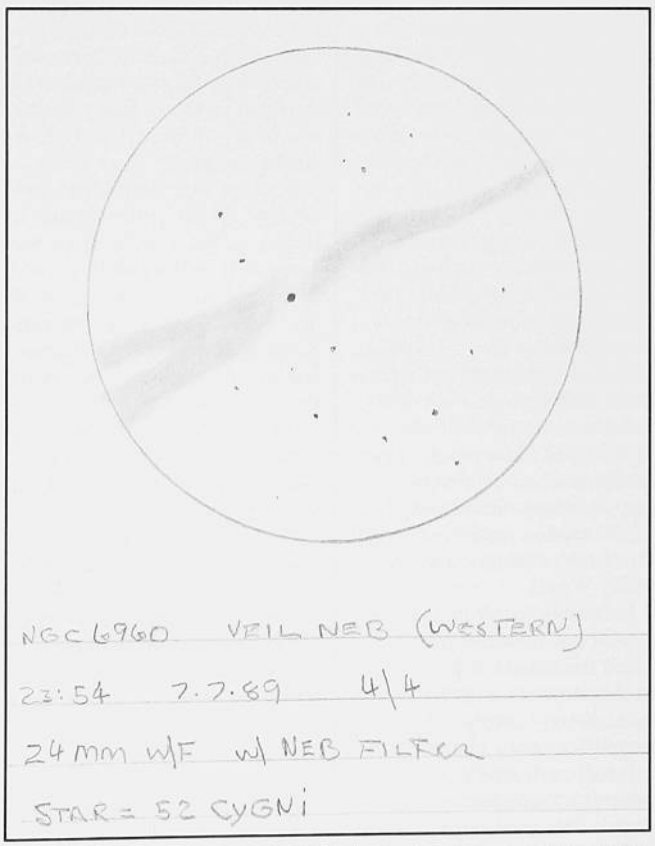
I've spent years looking for a way to capture what I see at the eyepiece of my 17.5-inch Dobsonian. Here in the northwest corner of New Mexico my observing site sits at 7,000 feet, lies well over a hundred miles from Albuquerque, and offers good skies for deep-sky observing. On most dark nights the Veil Nebula is clearly visible without a filter, as are many dark nebulae in the southern Milky Way.

How should one go about recording observations? Pastel sketches are realistic, but the rough texture of the paper requires a drawing about 8 inches in diameter to achieve fine detail. Black-on-white pencil allows fine detail in a smaller format, but you get a "negative" image of things. The sketches are durable. Astrophotography calls. The patient eye of the camera captures much more than we can glimpse in real time, but we see low-contrast detail that is simply washed out on film. Our eyes can also resolve fine details that are blurred by seeing during a time exposure.

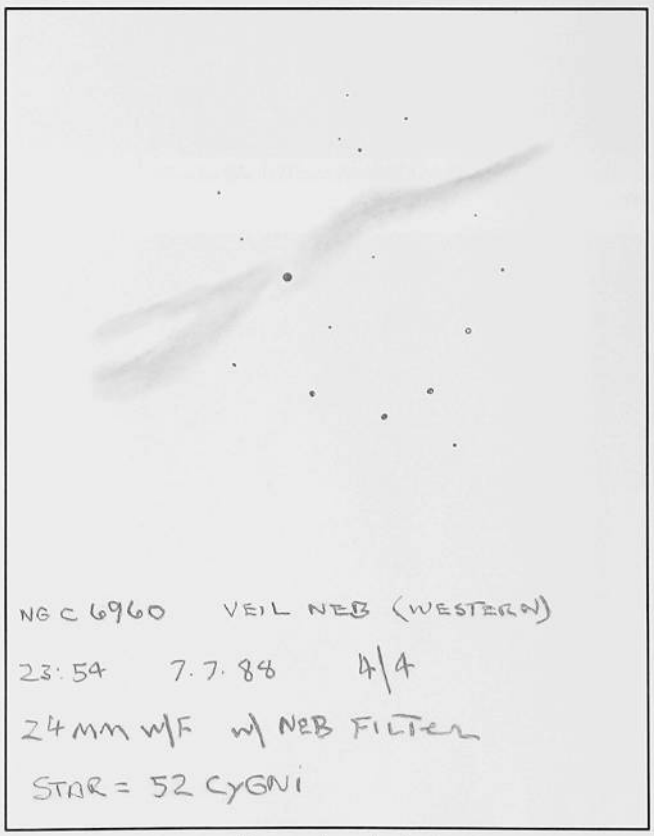
Long ago Dave Eicher wrote an article in *Deep Sky Monthly* describing his technique of shooting black-and-white photos of his pencil drawings, mounting the resulting negatives as slides, and projecting the images on a screen. Dave's method faithfully depicts what he sees at the eyepiece. However, can this be done without a camera? Can a print be made instead of a transparency? Yes. A sketch made on tracing paper can be used as a "negative." If the "negative" sketch is drawn the size of a desired print, you can avoid enlarg-



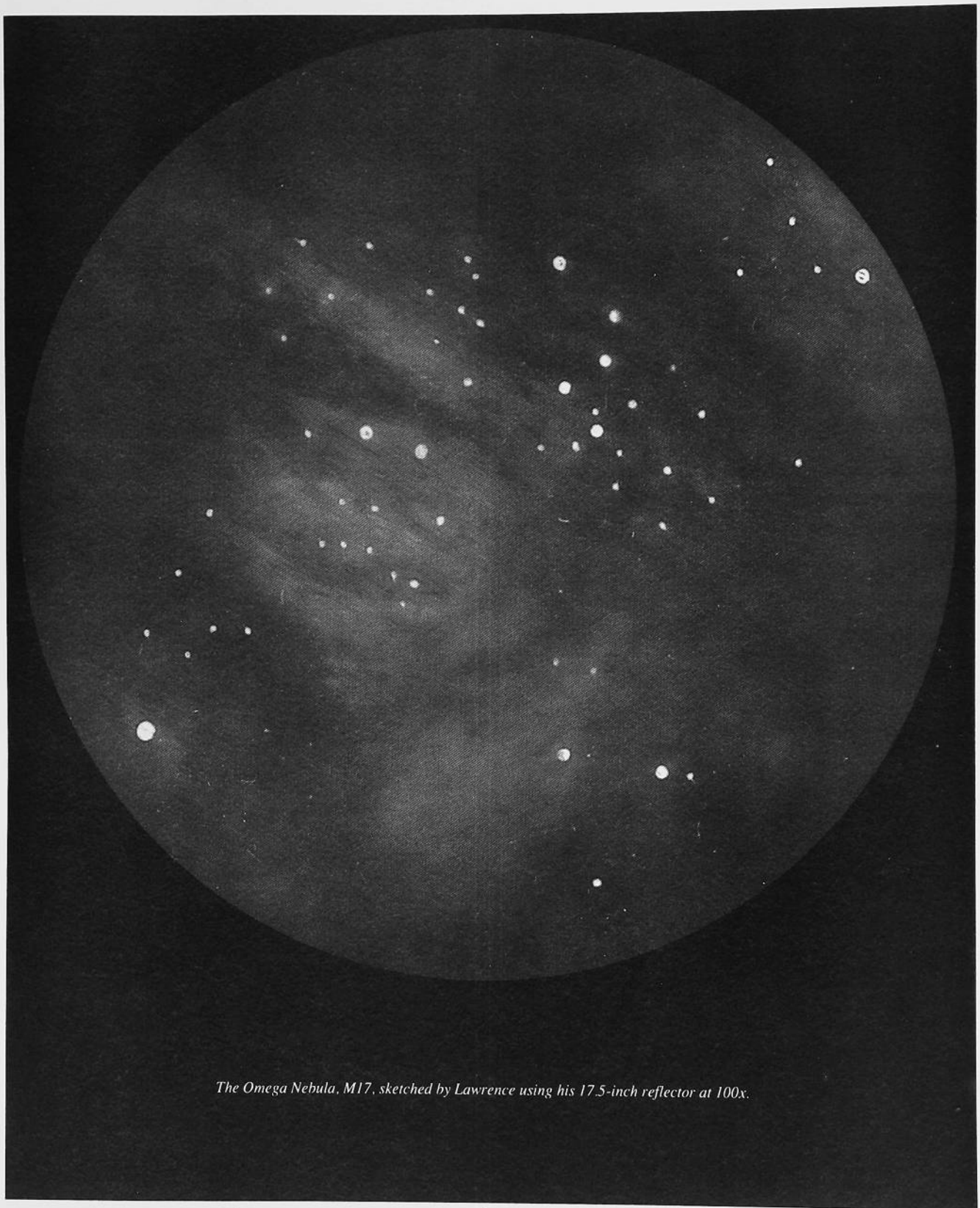
The Veil Nebula appears as a ghostly smear of light slicing through the field in this finished sketch. Lawrence used his 17.5-inch f/4.5 reflector with a nebula filter at 83x.



An original field sketch of the Veil Nebula showing placement of stars, stellar brightnesses, and shading representing nebulosity. All sketches in this article are by Jim Lawrence and were made using a 17.5-inch f/4.5 reflector.



Generation two: the original has now been sketched neatly onto a transparent sheet of Mylar film. This film will be contacted on photographic paper to produce the final result.

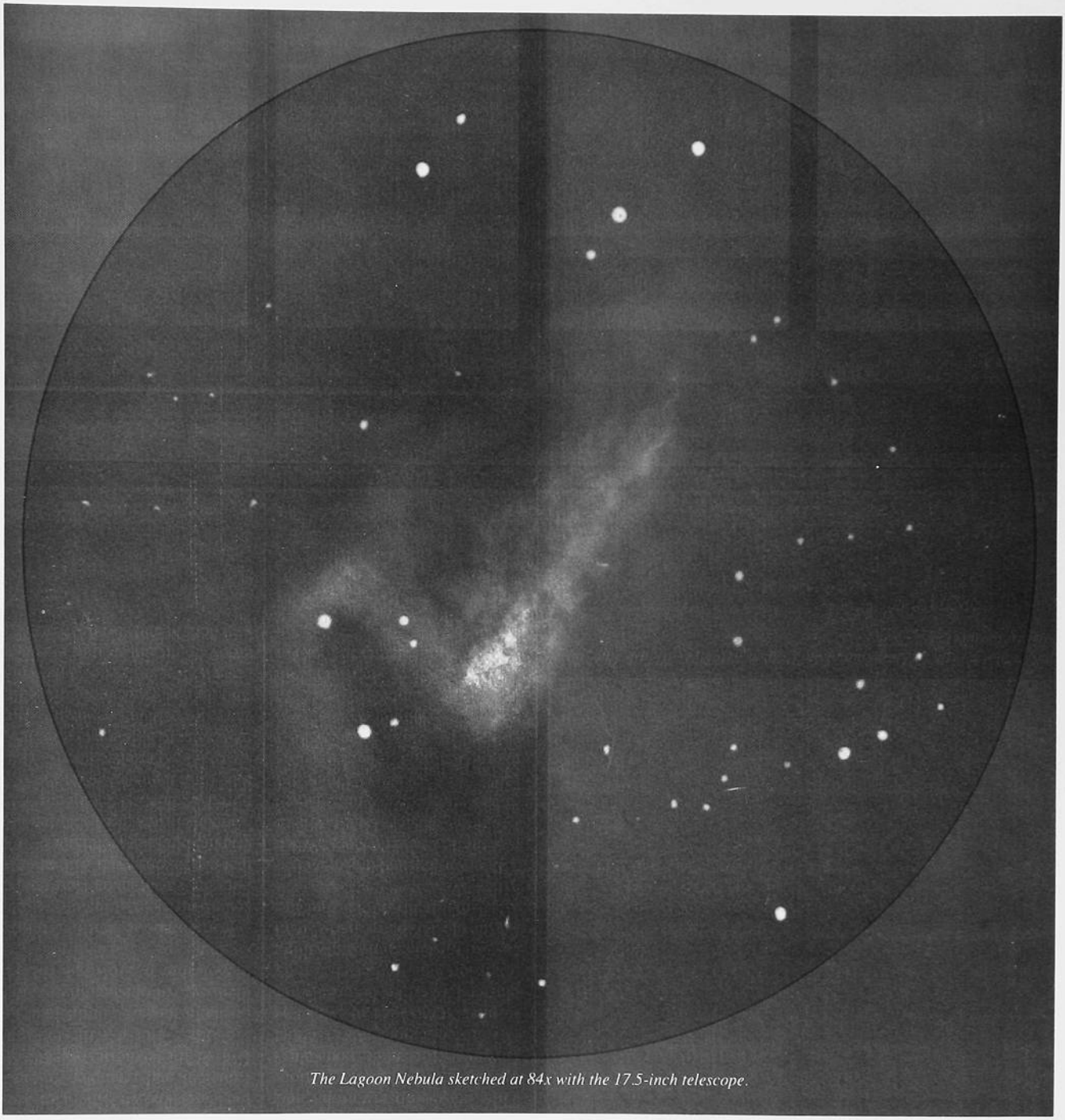


The Omega Nebula, M17, sketched by Lawrence using his 17.5-inch reflector at 100x.

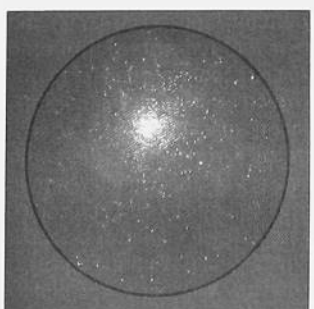
ing equipment. All that remains is simple black-and-white printmaking.

The prints accompanying this article were produced in this fashion. To make your own prints of sketches, follow this recipe. First, obtain a few sheets of bond paper, a sheet of black construction paper, several sheets of clear Mylar film of the thinnest sort you can find, a number one lead pencil, and a drinking glass. Fold and tear the bond paper and the construction paper into fourths. Fold and cut the Mylar sheets into fourths. With the drinking glass as a guide, draw a circle toward the upper end of each small bond paper section. You will now have sketch sheets with room at the bottom for notes. Draw a similar circle on one section of the construction paper, cutting out the circle with a sharp knife. This will serve as a mask for print work later. Discard the remaining construction paper or make a spare mask or two.

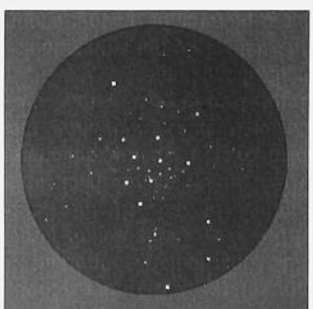
On the first clear, dark night, go outside with a clipboard, red



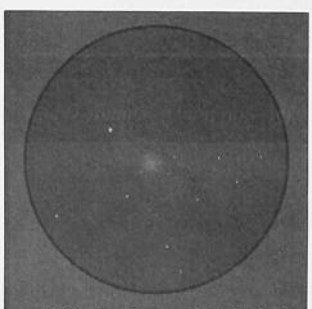
The Lagoon Nebula sketched at 84x with the 17.5-inch telescope.



M13, the Hercules cluster, sketched at 143x.

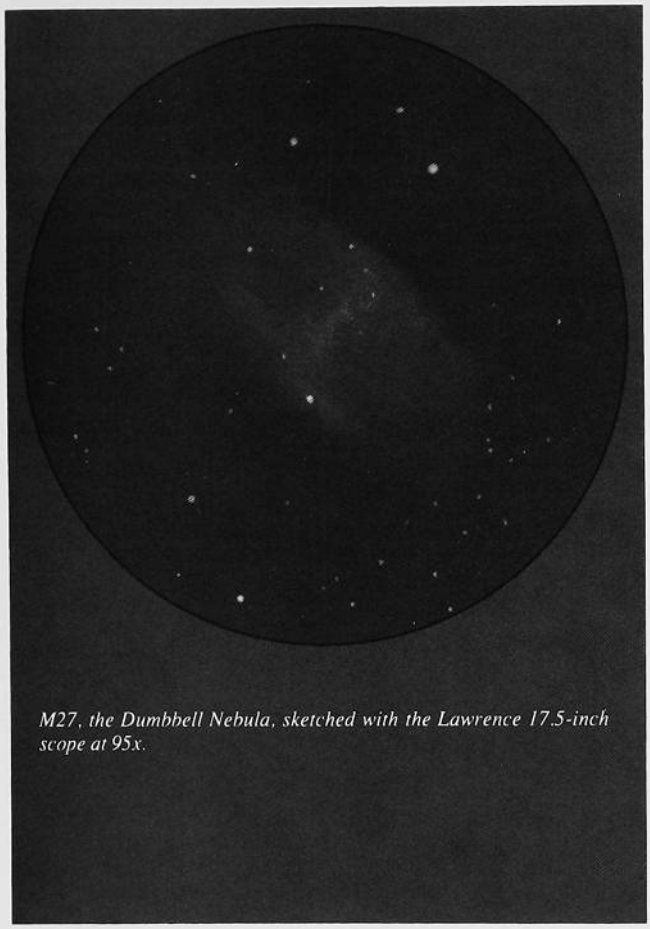


NGC 6231 in Scorpius sketched at 83x.

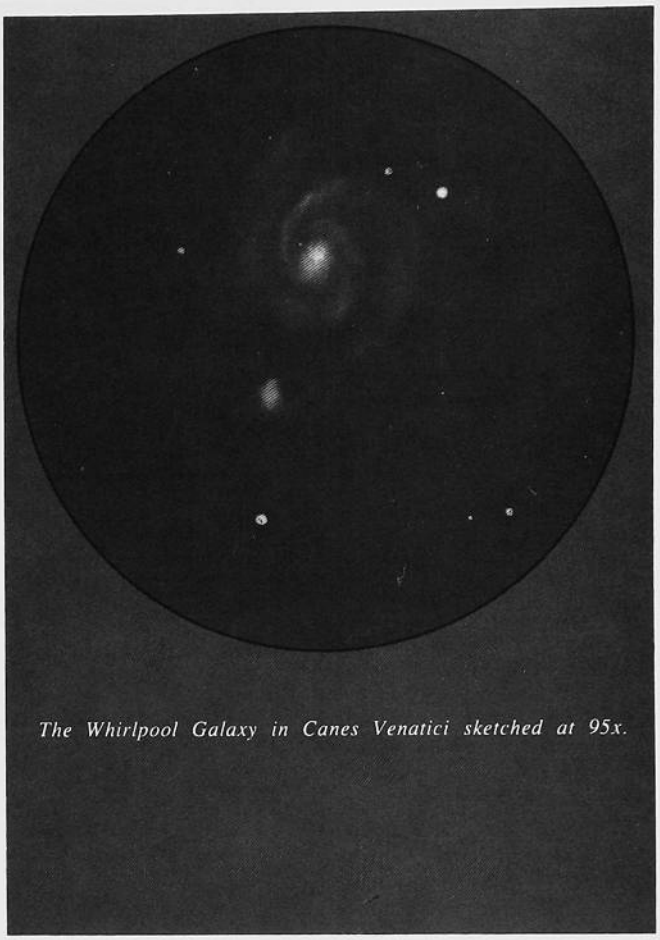


M56 in Lyra sketched at 192x.

The Orion Nebula sketched at 50x.



M27, the Dumbbell Nebula, sketched with the Lawrence 17.5-inch scope at 95x.



The Whirlpool Galaxy in Canes Venatici sketched at 95x.

light, sketch sheets, and pencil. Draw the object of your choice. Use your finger or a small cardboard sheet from an art store to smear nebulosity. Make brighter stars appear slightly bigger and darker than fainter ones. Accurately position stars within the viewing field. When the sketch is done, make notes about the time, object, eyepiece and telescope, seeing, and transparency. Annotate the sketch to amplify your artistic abilities.

In the light of day, place a sheet of drafting Mylar over your sketch. Trace the exact position of stars, lightly filling in nebulosity. Next lay the Mylar on a smooth, white surface and finish duplicating the field sketch. To get round stars without ink, use rubdown dots. A drafting template will let you draw stars down to 8th or 9th magnitude. When the mylar "negative" suits you, record pertinent information on the bottom.

If you aren't blessed with a darkroom, tape a piece of cardboard over the bathroom window, put a 7-watt red bulb in the light over the sink, and use a towel to block out light under the door. Use Kodak Dektol developer, fixer, and stop bath. Get some glass or plastic bottles to store the chemicals in and three Rubbermaid 6-inch or 9-inch drawer organizers. These small trays hook together on one edge and are just right for the size prints you will make. Get a pair of plastic tongs to handle the prints and Kodak 8-inch-by-10-inch Polycontrast Rapid II RC paper. Under red light, fold the paper, shiny side in, and tear it into fourths. Keep the sheets in a small box with a light-proof lid. Mix the chemicals using the instructions on the packages and store the mixture at room temperature. The solutions will feel cool to the touch and should be about 65°. The last item you'll need is a small piece of window glass cut to size of the sketch sheets and Mylar sheets. Lightly grind the edges to remove any sharp pieces and make it safe for handling.

Use a breadboard over the sink to provide a working surface and make sure you keep it dry. Pour the Dektol, stop bath, and fixer into each tray. With the red light turned on, place a sheet of paper, shiny side up, on the breadboard, and place the Mylar "negative" over the print paper with the pencil lead side up. Next put the construction paper mask over the negative, framing the sketch, and the glass on top to hold everything in place. Hold a flashlight (a penlight is adequate) about three feet above the assembled print and shine the light directly on it for about three seconds. Place the print paper in Dektol for about two minutes, moving it about to ensure even developing. Place the print in the stop bath for about fifteen seconds and in fixer for about three minutes. Rinse the print in the sink in cold water for four or five minutes with just a trickle of water running. Dry the print sitting on its edge so the water will run off. Don't touch or wipe it until fully dry.

Examine the print under a bright light. If the sky appears foggy, increase the exposure time. If the sky is dark and the stars are dull, decrease the exposure time. If adjusting the time doesn't cure this, brew more Dektol and be sure the proportions are correct and that it is not warmer than about 65°. After viewing the results of your efforts several times, you will be able to fine-tune both your negatives and darkroom activities. A black sky, sharp stars, and nebulosity will result.

After the prints suit you, they can be labeled with a Sanford fine-tipped marker or typed labels attached to sheets of paper with Carters rubber cement.

After a few printing sessions, the addition of a permanent mounting stand for the flashlight or penlight, an easel with a means to hold the print "sandwich," and a remote switch for the light could be added. The system will work with very low-tech equipment, though it certainly invites invention.

I would enjoy exchanging prints and ideas with anyone venturing into this twilight zone between photography and art.

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308 Mesa Drive
Aztec, NM 87410

Small Scope Showcase

A Night of Discovery

by Alister Ling

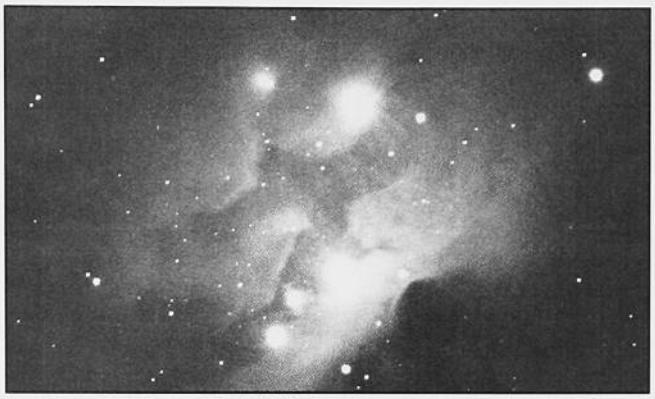
The thought of winter pushes some observers to the extreme of banishing their telescopes to the closet. Others bumble through a couple of quick, frozen sessions. The knowledgable observers on the other hand don't "brave" the cold, as they have adapted and learned to appreciate the tranquility of winter astronomy.

How wonderful it is to watch the brilliant jewels of the winter night float in a crisp, haze-free, black sky! Something reminds us at once of space: the absence of sound. The annoying mosquitoes are long gone, the sounds of the office are left behind a cushion of snow, and you're alone again with the universe.

As expected, those army surplus arctic boots are keeping your feet toasty warm; a much better buy than that extra Plossl. The wind barrier sure is great, and it even makes a nifty light shield. Now that you're comfortable, take your time, sit down if you can, and search for the nebulosity around the Pleiades.

The vast majority of reflection nebulae have a bright illuminating star that interferes with the observation. It is very easy to convince yourself that the halo surrounding the bright stars of the Pleiades is the nebulosity you've been looking for. Better check Aldebaran and the Hyades to make sure. . .if they too have "nebulosity" then your optics are scattering too much light.

Make sure that your mirrors and lenses are clean, and above all, free of dew or frost. Owners of refractors and Schmidt-Cassegrain telescopes (SCTs) should look into purchasing heated dew caps. Their objectives and corrector plates are the most susceptible to dewing over. The dew cap can double as a light baffle to keep out stray light. The eyepiece is the next weakest link: it has a small mass and cools quickly under clear skies, which leads to the formation of dew on its surfaces. Oculars with short eye relief (especially type II Naglers) have the added problem of condensing the moisture released by the observer's eye. An eyepiece warmer should be high on the list of required accessories.



Top: NGC 1973-5-7 is a complex of nebulosity north of the Orion Nebula. Martin C. Germano used an 8-inch f/10 SCT, 103a-F film, and a 20-minute exposure. Above: M41 is a brilliant star cluster. Martin C. Germano used an 8-inch f/5 reflector, 103a-F film, and a 15-minute exposure.

Another excellent region of bright reflection nebulae that is often overlooked is the triplet of **NGCs 1973-5-7** surrounding the bright stars just north of the fantastic Orion Nebula. Patient observers with 3-inch scopes have reported them to be visible. Since there is little emission to be found here, nebular filters are of no help.

As Lucian Kemble of Calgary, Alberta, says, "Subtle is the light."Contrast and patience are the most important factors in observing reflection nebulae, not simply sheer aperture. Refractors can have the edge over "light buckets" when it comes to the brighter objects. Never assume that your telescope is too small and you will be pleasantly surprised.

Even the most light-polluted city bound observer can share in winter's delights. **NGC 2169** is a gem of an open cluster located in Orion's club arm. The handful of bright stars form a remarkable "37" pattern. Of course if you are using a star diagonal the number will appear backwards. You may have to twist your head around a bit before you can see it. There are fourteen stars brighter than 11th magnitude, so even a small refractor does an admirable job briniging this group to light.

The "top right" star of this rather angular "3" is the brightest in the cluster and carries the number **Σ848** in Wilhelm Struve's double star catalogue of 1827. Σ848 is fairly easy as double stars go: there is a 2.5" separation of the 7th-magnitude primary and the following (easterly) 9th-magnitude companion. Use a power of 150x or more (if the atmosphere is steady enough) and try and pick out the four other components listed in *Sky Catalogue 2000.0*, Volume 2.

Moving southward, we can find another cluster that is easily viewed from the city: **M41**. Just short of 3° south of Sirius, this cluster can be seen with the naked eye on a dark night. In any telescope, we can see some twenty-five bright stars spread over almost 40'. A host of fainter stars become visible with larger instruments or country skies. At a distance of 2,300 light years, M41 spans some 20 light years across.

Can you see the bright central star tinged with red? From a frigid rooftop in downtown Montreal a few years ago, I didn't notice this with a 10-inch scope, yet other observers say it us very prominent. It just goes to show that despite spending 15 minutes making a sketch of an object, one can still miss something quite obvious!

One thing I did notice was that may stars are arranged in trapezoids, that is a group of four stars where two sides are parallel. People also mention that many stars seem to be arranged in curving lines. Knowing that our brain has its own image processing and pattern recognition "programs," why not try the following experiment?

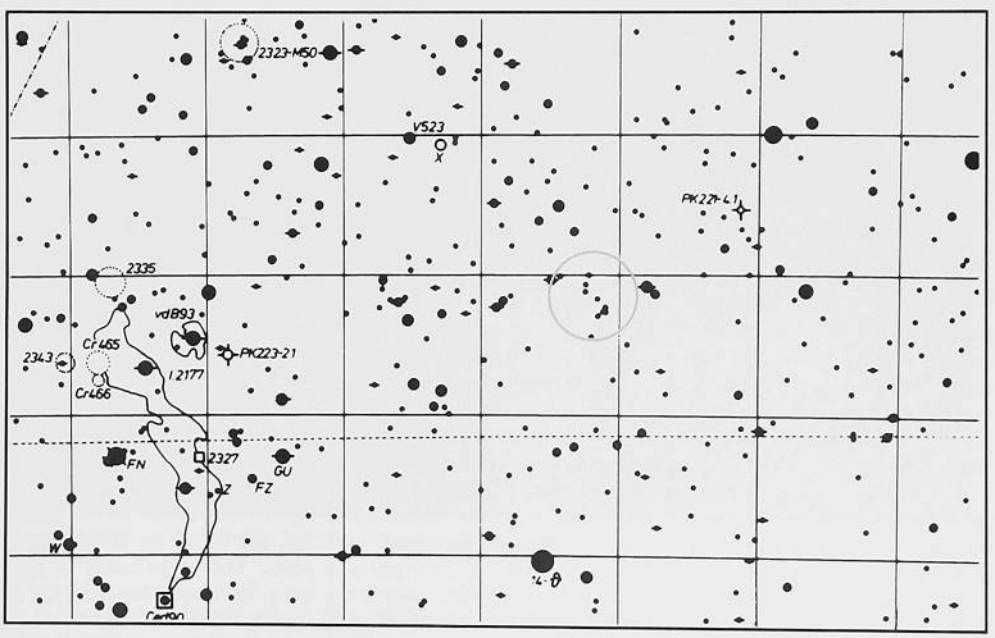
When you go observing, take a sketch pad out with you and mark down in line form the various curving star chains you see through the eyepiece. You may want to plot a few of the brighter stars and especially the direction where north lies. On a different night make another sketch, and then compare the two; does your brain recognize the same patterns?

An aura of discovery surrounds **M50.** A sparkling open cluster in Monoceros, it lies about one third of the way from Sirius to Procyon. Although the intrepid comet hunter Charles Messier discovered in 1772 while following a bright comet, he was not the first to report it. It seems that sixty years earlier, Cassini stumbled upon the cluster but the best he could manage for a position was "in the area between Canis Major and Canis Minor." Not very impressive for a scientist.

The cold must have set in deeply one winter night; just as with M41, I failed to notice the rather prominent red star in M50. Maybe I missed the red stars because no one told me to look for them; I had not yet learned to "see" for myself. With some eightly stars packed into a circle half the size of the Moon, M50 has never failed to lift my chilling spirits. Dark country skies turn this object into a splendor when one sweeps the area with a low-power telescope. The surrounding starfields are wonderfully rich, though fainter than the ones in Sagittarius.

As you can see on the *Sky Atlas 2000.0*, a number of less remarkable yet still beautiful clusters are scattered in the region of M50. Even today, you can still explore and discover things for yourself. By letting the sky be his guide, Randy Pakan of Edmonton, Alberta, made his own discovery last winter: in star-hopping from Sirius to M50 Randy kept losing his way and ending up on a string of stars which make up a backwards "3."

Pakan's 3 is not a true cluster however, but simply a collection of a handful of 10th-magnitude stars: an asterism. The mighty Herschels missed it as their telescopes permitted a low power of only 120x or more. At 65x the curving line of fifteen stars fits snugly in the 50° field of the eyepiece in my 12.5-inch telescope. The northern tip sports an easy double star for an added sparkle. Because the "3" is about 40' across, you need a nice wide field to enjoy the view. Pakan's 3 is on the photo on page 93 of the February 1988 issue of ASTRONOMY as well as the accompanying section of *Uranometria 2000.0*.What other hidden treasures can you stumble on in the winter night?



Top: Orion's Great M42 is visible to the naked eye as a fuzzy patch of light. Look for it below Orion's belt. Paul Roques used a 16-inch f/4.5 reflector, hypered Tech Pan film, and a 60-minute exposure. Above: Pakan's 3 is plotted on a section of Uranometria 2000.0 *in this finder chart. Copyright 1987 Wilmann-Bell, Inc.*

Let's continue our voyage of discovery back to the finest object in the winter skies: **M42,** the great Orion Nebula. There can't be anything left to discover here! Or can there? Last winter I made a discovery about the Orion Nebula that astounded me, but in hindsight I should have expected it: M42 is different in an Hβ filter than through a UHC! I won't spoil the fun for you so you can go and see for yourself. Try using medium powers.

To fully appreciate the beuaty of an object like M42 one needs to spend a great amount of time simply looking up. As you become familiar with the spread of wonderful nebulosity, your eye naturally begins to seek out subtle detail. Likewise, every time you listen to the Bach Double Violin Concerto or Mozart's "Jupiter Symphony," your ears begin to hear the complex interplay of the accompanying instruments. A musical work contains more than the melody, just as a nebula is made up of more than the brightest parts.

I highly recommend the use of a nebular filter like the UHC. It is not a luxury but an important part of your equipment, more so than any other eyepiece. It has opened my eyes on a scale from observing in the city to severe shock under the dark skies of the Australian outback.

Ah, winter observing. . .one of the nicest things about the cold night is that after absorbing the majesty of the night sky for some five hours, you can still make it to bed by 11 p.m.! Treat yourself.

#303-16316-100 Street
Edmonton, Alberta
T5X 5J6 Canada

Double Stars
The UU Aurigae Group
by Brian Skiff

Buried in the long lists of T. W. Webb's classic *Celestial Objects for Common Telescopes* are many treasures casually tossed out for the visual observer. Under Auriga, in the entry for Σ929 (ADS 5208) is mention of "a beautiful triangle" of stars between Σ929 and Σ928 (ADS 5191), 50' north and slightly west. Further mention is made of a 6th-magnitude red star, referred to as Es-Birm 192, from an 1890 catalogue of such stars by Webb's successor, T. E. Espin, and John Birmingham. Yet another pair of stars is noted east of the red star.

All this bore investigation last winter both in catalogues and at the eyepiece. The region turns out to be quite interesting, because ten or more double or multiple stars fall in a 2° area around the bright red star, now known to be a variable carbon star designated UU Aurigae. As part of my inquiry, I asked Canadian observer Paul Brown for corroborating observations; some of his remarks are incorporated below.

UU Aurigae makes a good jumping-off point for star hopping in the region. Last winter it stood at about magnitude 5.5 visually, about as bright as ϕ^3 Aurigae (V=5.2) and 51 Aurigae (V=5.7), which are about 1-1/2° north (and form a nice blue-white and orange pair for binoculars, by the way). The fourth edition of the *General Catalogue of Variable Stars* lists UU Aurigae as a semiregular variable with an extreme range of a little over two magnitudes and an average cycle length of 7-1/2 months. The visual observation recorded in the Espin-Birmingham catalogue, however, suggests it rarely strays far from magnitude 6, so don't expect large variations.

S. W. Burnham measured a faint star near UU Aur at the turn of the century. The *Washington Visual Double Star Catalogue* (*WDS*) lists this star as magnitude 10.7. However, neither Paul nor I was able to discern it in good seeing at high power. Inspection of the POSS prints shows that the companion is at least three magnitudes fainter than advertised, so much greater optical power than our 6- and 8-inchers will be necessary to see it. Reports welcome. In any case, you'll find the primary a treat to look at (NGC compiler John L. E. Dreyer called it "splendid red").

In my 6-inch refractor I spotted a faint, wide pair just 4' southeast of UU Aur. I estimated magnitudes 9 and 10.5, 15" separation in p.a. 255°. Later on the POSS prints I found my magnitudes about three magnitudes too bright (I was still getting used to the remarkable definition of the apochromat at the time); the other estimates were very close (16" and p.a. 257° measured).

The pair mentioned in Webb's book to the east of UU Aur is ADS 5245. It was an easy object at 80x in the 6-inch. Using the Lowell 21-inch photometric telescope, I measured the magnitude difference (delta m) of the components to be 1.6, compared with 2.0 implied by the WDS data.

A little farther southeast of UU Aur is **ADS 5240**, a relatively close, faint pair. I found it barely resolved at 80x and not a lot easier at 165x. Paul and I agreed that delta m is at least 1.0, not 0.3 as the *WDS* suggests. The magnitudes in the table have been adjusted for a delta m = 1.2.

About 1/2° south is ADS 5221, a fairly close but nearly equal pair. Although Paul and I both needed moderately high power to resolve it, it presented no particular difficulty. The two stars have a proper motion of 0.13" per year, which suggests that they are relatively close to Earth. The photometric colors suggest a pair of dim K dwarfs.

ADS 5208, mentioned above, is a pretty easy object for moderate apertures, and I could resolve it at 50x in the 6-inch. Webb noted a color contrast here (yellowish and very blue), probably caused by the brightness difference between the two stars. The photometric colors for this object also suggest a nearby pair of K dwarfs. Neither Paul nor I could make anything of ADS 5201, 40' south. Perhaps the secondary is fainter than catalogued.

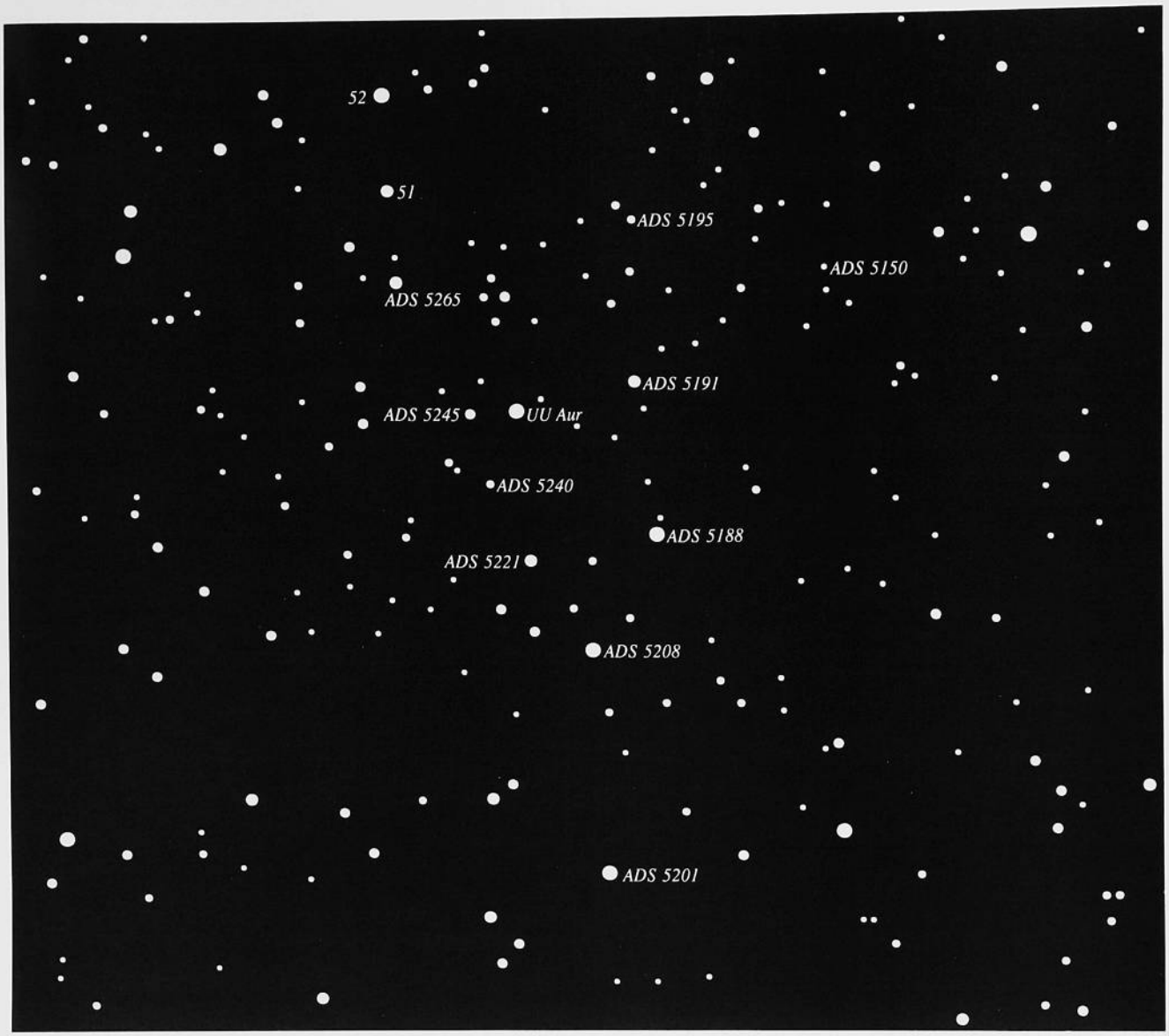
The "beautiful triangle" Espin mentions is **ADS 5188**. It consists of an orange, magnitude 6 and two pretty much fainter companions about 45" northeast and southeast. It is a good object for small telescopes and best viewed in your lowest power eyepiece — certainly no more than 20x is necessary. I found the colors (orangish for the primary and pale blue for the two fainter stars) clearly distinguishable although not especially striking. If you have a large instrument, try to resolve the C (southeastern) component: it is a nearly equal half-arcsecond pair. Available proper motions show that this trio is an optical grouping, because the stars do not share a common grouping.

Farther north (or nearly west from UU Aur) is perhaps the nicest pair in the region, **ADS 5191**. Because the components are moderately close and fairly bright, it was a neat object at 80x in my 6-inch. Paul and I agreed that the delta m is about

The UU Aurigae Group

Name	R.A. (2000) Dec.	Mags.	Sep. (″)	P.A. (°)	Date	Est. MK Spec. Type
ADS 5150	6h31.8m 38°54′	V=11.5, 11.6	4.5	16	1944	g0v
ADS 5188	6h34.3m 38°05′	AB:V=6.7, 9.2	42.8	74	1950	k0iii + f1v
		AxCD:V=6.7, 10.0	45.9	117	1950	k0iii + f9v
		CD:V=10.6, 11.0	0.5	109	1957	f9v
ADS 5191	6h34.7m 38°25′	AB:V=7.6, 8.6	3.5	132	1968	g2v
ADS 5195	6h34.8m 39°06′	AB: 9.6, 11.4	0.3	47	1922	K0
ADS 5201	6h35.1m 37°04′	V=7.4, 11.1	2.6	74	1958	k2iii
ADS 5208	6h35.4m 37°43′	V=7.4, 8.5	6.1	24	1968	k1v
ADS 5221	6h36.2m 38°00′	V=8.5, 9.0	1.3	279	1957	k0v
UU Aur	6h36.5m 38°27′	V=5.5, 10.7	17.9	222	1908	C5, 3-C7, 4(N3)
anon	6h36.7m 38°24′	~12, ~13	16	257	1951	—
ADS 5240	6h36.9m 38°13′	V= 9.7, 10.9	2.2	30	1977	f5v
ADS 5245	6h37.3m 38°26′	V= 8.8, 10.4	10.3	294	1929	a7iii/v + f5v
ADS 5265	6h38.4m 38°49′	9.6, 13.5	4.6	54	1925	—

ADS 5150 – V = 10.77, b-y = 0.38; ADS 5188 – V(A) = 6.66 (two additional sources other than my measures), b-y = 0.63 (B-V = 1.00 according to Oja), V(B) = 9.18, b-y = 0.22, V(CD) = 10.02, b-y = 0.36; ADS 5191 – V = 7.25, b-y = 0.42, mags calculated assuming delta-m = 1.0; ADS 5201 – V = 7.40, b-y = 0.69; ADS 5208 – V = 7.03, b-y = 0.51, relative position fixed since 1830; ADS 5221 – V = 7.92, b-y = 0.50; UU Aur – V = 5.61 (21 Mar 1988), b-y = 1.73, the Yale Bright Star Catalogue gives B-V = 2.61, anon – measurements from POSS prints, visual delta-m ~ 1.5; ADS 5240 – V= 9.42, b-y = 0.30, mags calculated assuming delta-m = 1.2; ADS 5245 – V(AB) = 8.55, b-y = 0.18, V(A) = 8.78, b-y = 0.15.



Finder chart for the UU Aurigae group, showing positions of doubles and field stars. The chart center is approximately 6h 35m, +38°.

1.0, not 0.6 as catalogued. The faint, distant component noted in the table is too far away to seem related when observing the object visually.

ADS 5195 is also a triple, but the AB pair is extremely close and will require a large aperture for resolution. (There are no measures since 1922, however, so they may not be in the orientation described in the table!) The distant C component was easy in the 6-inch, but it is not as faint as magnitude 13, as the *WDS* states, but more like 11.5 or 12 (verified on the POSS prints).

Off on the northwest edge of our region is ADS 5150. It is relatively tough to find because it is only 11th magnitude. I identified the pair as a fuzzy star at 80x and could resolve it — but not easily — at 165x.

As a challenge to big-scope owners, I offer **ADS 5265**, about half a degree northeast of UU Aur. Neither Paul nor I could deal with it. The *WDS* lists a magnitude 13.5 companion only 4.6" away, which makes it a tough object that I'd guess will require a sharp 12-1/2-inch to pick up, assuming the magnitude estimate for the secondary is correct.

I made photoelectric measures of the combined light of all but two of the ADS pairs in this list together with a bunch of standard stars with the Lowell 21-inch. As it turned out, the night was a poor one: there were some thin cirrus present but not noticed during the observations. Thus the results are not of as high quality as expected: the V magnitudes are accurate to about 0.03 or 0.04. The colors, however, are very good: the transparency was changing very slowly, so the blue and yellow magnitudes were about equally affected by cloud and their differences came out very close to the standard system.

The measures were made using Stromgren *b* and *y* filters and were transformed to the more familiar B and V system. I adjusted the magnitudes of the stars in the table to add up to the desires V magnitude. Most required adjustments of only a few tenths. The stars not measured lack the "V" = qualifier in the magnitudes column. Using the inferred B-V colors, I estimated the most likely spectral types; these are given in the table in lower case. Single entries here refer to the average or combined type. Only an HD type exists for ADS 5195 (upper case); the carbon star classification for UU Aur comes from the *Yale Bright Star Catalogue*. The spectral types are useful in assigning colors to the stars objectively. The original "combined light" photometry is given in the notes along with other remarks. Almost all the remaining information in the table is extracted from the *WDS*.

1400 West Mars Hill Road
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Variable Stars
R Cor Bor Fades Away
by David H. Levy

Winter observing usually means leaping outdoors for brief frozen observations and a quick look at M42 and the Pleiades before rushing back inside where proper people belong. If you care to put a little more effort into it, a treat awaits you this winter.

This winter the odd variable star **R Coronae Borealis** may be worth a little frostbite. This usually docile 6th-magnitude variable has started dimming. For a couple of good reasons the term "backwards nova" decribes this star. Usually a nova stays at minimum until the day of its explosion and then rises by several magnitudes over a short period. R Coronae Borealis, however, does the opposite. It stays at maximum for long periods of time, anywhere from several months to a decade. It is usually a good test for sky clarity: if you can see it without optical aid, you have a good sky. But occasionally, without warning, R Cor Bor plunges as many as eight full magnitudes to a minimum of 14th magnitude. At minimum it could be a difficult target for an 8-inch telescope.

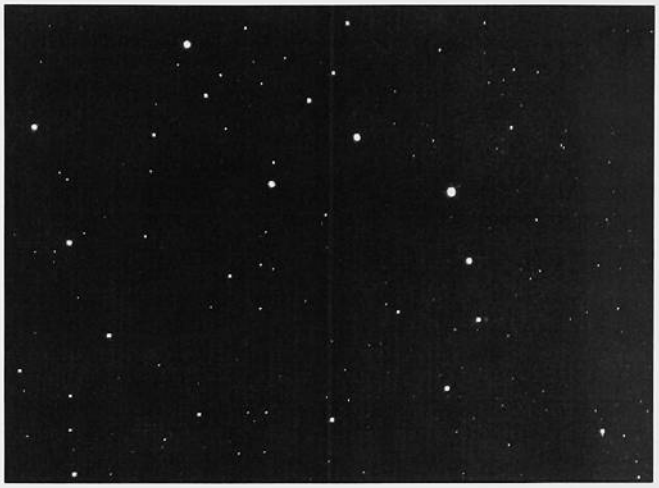
The other novalike property of R Cor Bor (as variable star observers affectionately call this star) is that an eruption really does take place. However, instead of a brightening star (as is usual for novae), in this case the eruption blocks the star's light. The eruption produces a shell of carbon particles that absorb the star's light.

During the past twelve years R Cor Bor has shown a number of declines. I remember the 1977 event well; it was the last day of February, and I was visiting family in New Orleans in the middle of Mardi Gras. Earlier that week I had spent some time under a hazy sky observing evening variables and was delighted I had chosen variable stars as an observing interest. I had two pairs of binoculars and a driveway, but these suited me well for what was to about happen.

Just before I went to bed, I decided to check the sky again and observe three more variables, X and g Herculis and R Cor Bor. The two stars in Hercules are bright semiregulars that change very slowly, so they held no surprises. But when I turned the binoculars to Corona Borealis, I immediately knew something was wrong. The pattern of the constellation was wrong — the star R Cor Bor was missing!

I could see the magnitude 5.9 standard and even the magnitude 6.5 star. With mounting excitement and my memory of R Cor Bor's easy visibility only a week earlier, I went inside and got a larger pair of binoculars. Now I could see the magnitude 7.2 and 7.8 standards, and there was R Cor Bor dimly glowing at magnitude 7.1! That was the week R Coronae Borealis began a slide that didn't end until it slipped below 14th magnitude. R Cor Bor remained faint the rest of that year.

Located right in the middle of the semicircle of stars that form Corona Borealis, R Cor Bor is near two fainter stars, one a 7.2-magnitude object and the other shining at magnitude 7.8. I have used the 7.2 star as a test for pristine observing conditions. Occasionally on dark Arizona nights I can see it without optical aid. You should observe R Cor Bor every clear night — even if the star has returned to maximum — in case it starts to drop again. The start of a minimum may be slow and teasing: R can drop to magnitude 6.3, then recover, and then undergo a shallow drop of two fifths of a magnitude. R Cor Bor can fall as low as magnitude 6.4 without plunging all the way to minimum. But if the star on your first observation has a magnitude of 6.2 or 6.3, and the following night you find a 7.1 star, then the chances are good the star is rapidly dimming. When R Cor Bor is down, frequent observations become very important.



R Coronae Borealis shines brightly in this photograph but is currently in the act of fading away. Photo by Greg Walz-Chojnacki.

R Cor Bor has reached a low point many times during its career. The first was noted around 1795, and in the mid-1850s a drop alerted observers to study the star seriously. From 1896 to around 1902, R Cor Bor showed virtually no activity, but from 1908 to 1912 four minima occurred in rapid succession. From 1923 to 1934, R Cor Bor was virtually constant at 6th magnitude, except for one quick and shallow minimum. Lasting over a year, the minimum of 1977 was one of the deepest and longest on record.

Several years after the 1977 decline, R Cor Bor dropped deeply again. Then in late 1985 the star dropped to about magnitude 10.5, coming back in time to have what is known as a shallow minimum, to about magnitude 7.3, in April 1986.

Who was the first to detect the current decline? According to circular 4633 of the International Astronomical Union, the star's brightness was gradually declining as early as July 11, 1988. Peter Collins of Scottsdale, Arizona, reported it as magnitude 6.3 on July 16, and a day later Charles Scovil at Stamford, Connecticut, reported magnitude 6.4. On July 25, Paul Sventek of Houston, Texas, estimated it at magnitude 7.0, and the decline was on. It is difficult to say who among these and other observers was the first, especially because Corona Borealis was almost overhead and many observers were reporting to the AAVSO.

A few other R Cor Bor-type stars are visible this season.

040053 **XX Camelopardalis**. Photographic magnitude 8.7 to 10.3.
225859 **UV Cassiopeiae**. Photographic magnitude 11.8 to 16.5.
1237-53 **UW Centauri**. Photographic magnitude 9.6, fainter than 13.
054319 **SU Tauri**. Visual magnitude 9.5 to 16.0.

Peter Collins, one of the AAVSO's most prominent observers, has suggested that we have an R Cor Bor celebration. Like the solstice, it will be held as soon as R Cor Bor is definitely on its way back up. When you read this, the party may already have taken place and R Cornoae Borealis will be shining brightly again. It is also possible that this fascinating star will still be very faint.

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Scanning the Literature

The Latest Research News

by Brian Skiff

A bright new quasar has been identified in a survey of *Infrared Astronomical Satellite (IRAS)* objects by Berkeley astronomer Michael Strauss and collaborators ("A Newly Discovered IRAS QSO Close to the Galactic Plane," *Astrophysical Journal Letters (ApJ Letters)* **332**:L45, September 15). The group is getting spectra of nonstellar objects near the galactic plane that appear bright in the infrared.

The object in this paper surprised them because its redshift ($z = 0.0571$, corresponding to a velocity of about 17,000 km/sec) was unusually high. Follow-up observations showed spectral emission features characteristic of a quasar. Later they observed the V magnitude to be 13.55, which make it the fourth-brightest known quasar.

The catch? It's in Carina, at equinox 1950 position 9h14m59s.3 and -62°06'55". So Southern Hemisphere observers have an observing target for their next night out this austral summer.

CCD imagery is being applied with great success in identifying the central stars of planetary nebulae. The unambiguous identity of the central star in NGC 7207 has been made by George Jacoby at Kitt Peak ("Identification of the Central Star in NGC 7207," *ApJ* **333**:193, October 1). This bright planetary has long been known as an unusually dusty object located behind a mottled veil of interstellar dust; visual observers will note the surrounding starfield is rather poor despite being smack in the Cygnus Milky Way.

Because of the high dust content of the nebula, the contribution of continuum light to the object's brightness is quite high compared to the expected nebular emission-line flux. For this reason the central star is washed out and was not securely identified at visible wavelengths until now (it is extremely bright in the infrared and radio).

Jacoby's technique involved taking CCD images in the Hβ emission line and in a continuum band somewhat to the red that includes only very weak emission lines. The Hb image was then subtracted from the continuum images. Other analysis if these images yielded a V magnitude of 16.3 ± 0.3, in accord with that determined by others from spectroscopic measurements.

Karen Kwitter was joined by Thomas Lydon to use CCD pictures to identify central stars in several other objects ("Identification of Faint Central Stars in Extended, Low Surface Brightness Planetary Nebulae," *Astronomical Journal (AJ)* **96**:997, September). Stars were found in seventeen of twenty-five objects examined using U, B, or V-band CCD frames. V magnitudes are estimated for the stars detected. The interesting collection of photos with the article includes NGC 6852 and a number of Abell and Sharpless objects frequently sought by visual observers using narrow-band sky-supressing ("nebula") filters.

Two of three new studies of the stellar membership in the Orion Nebula appeared back-to-back in the June *AJ*. The first paper is by a group led by Yale astronomer William van Altena ("The Velocity Dispersion of the Orion Nebula Cluster. I," *AJ* **95**:1744). Proper motions of unusually high accuracy of seventy-three stars brighter than V~12.5 all lyingwithin approximately one-half degree of the Trapezium are reported.

The measures definitely lay to rest the previously claimed expansion of stars from the center of the cluster, which probably arose from a systematic error in the earlier measures. The two brightest Trapezium stars, however, do have motions that will put them outside the cluster in less than a million years and are apparently currently being ejected from the cluster.

Tables included with the article provide summaries of magnitudes and spectral types in addition to much needed cross indices to other lists.

The second paper is by B. F. Jones and Merle Walker at Lick Observatory ("Proper Motions and Variabilities of Stars near the Orion Nebula," *AJ* **95**:1755). Despite the fact that it covers much the same ground as the van Altena *et al.*. work, this study includes over a thousand stars in the half-degree area centered on the Trapezium, thanks to the light-gathering power of the Lick 3-meter reflector.

The Lick plates have only a twenty-three-year baseline compared to the seventy-seven-year interval of the other study, which used archive plates from various long-focus refractors. The accuracy of the proper motions is lower by a factor of five to ten, yet they evidently give similar overall results, and the separation of field stars from the Orion complex is about as good. A great set of finder charts includes the core of the cluster very close to the Trapezium. Precise coordinates, cross-identifications, and variable star names are summarized in tables.

If it sounds as though a thorough new visual survey of Orion is now in order, you're right!

Several new photometric studies of star clusters have been published in recent months. A photometric survey of globular clusters near the galactic center, forming part of a dissertation project, was published by Taft Armandroff ("Color Magnitudes and Diagrams for Six Metal-Rich, Low-Latitude Globular Clusters," *AJ* **96**:588, August). Color magnitude diagrams (CMDs) are shown for NGC 6316, NGC 6342, NGC 6539, NGC 6760, and Palomar 8.

None of these objects had been studied before because the objects lie in crowded fields behind layers of obscuring dust. Hence, the CMDs were expected to be difficult to interpret because of the inability to distinguish field stars from cluster members. Even with state-of-the-art digital processing of CCD frames the CMDs are cluttered, but they are a lot better than nothing. In particular, the cluster distances are much better established than earlier estimates, which were often little more than guesses.

Another Palomar cluster had also been studied ("Deep Photometry Globular Clusters. XI. Palomar 12: The Youngest Galactic Globular Cluster?," R. G. Gratton and S. Ortolani, *Astronomy & Astrophysics Supplements (A&A Suppl.)* **73**:137, April). Again, CCD photometry is presented for this sparse cluster down to magnitude 23.5. The brightest cluster stars are about V magnitude 15.5 and thus should be resolvable in large amateur scopes from a dark site.

The distance to the cluster determined here is about 20 kiloparsecs. Young? Well, 9.5 billion years, but this is a rough guess at best. A chart based on one of the CCD images is provided to identify individual stars.

New photometry and proper motions for a brighter cluster are presented by Kyle Cudworth ("Astrometry and Photometry in the Globular Cluster NGC 6712," *AJ* **96**:105, July). The astrometric measures, based on archival Yerkes refractor plates, and the photometry reach to V magnitude 18. The motion of the cluster is nearly zero, so field stars (in the foreground) were easily identifiable by having even very small motions relative to the cluster.

The photometric measures led to a distance estimate of 6.5 ± 0.6 kiloparsecs. The brightest cluster giants are V magnitude 13.5 or so, hence the cluster is resolvable in a 6-inch or 8-inch telescope.

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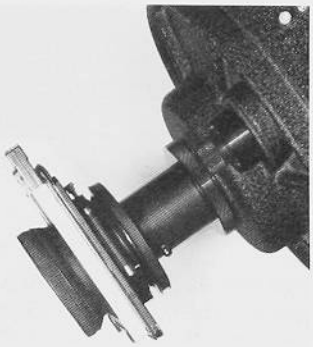

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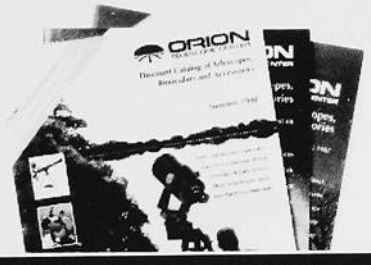

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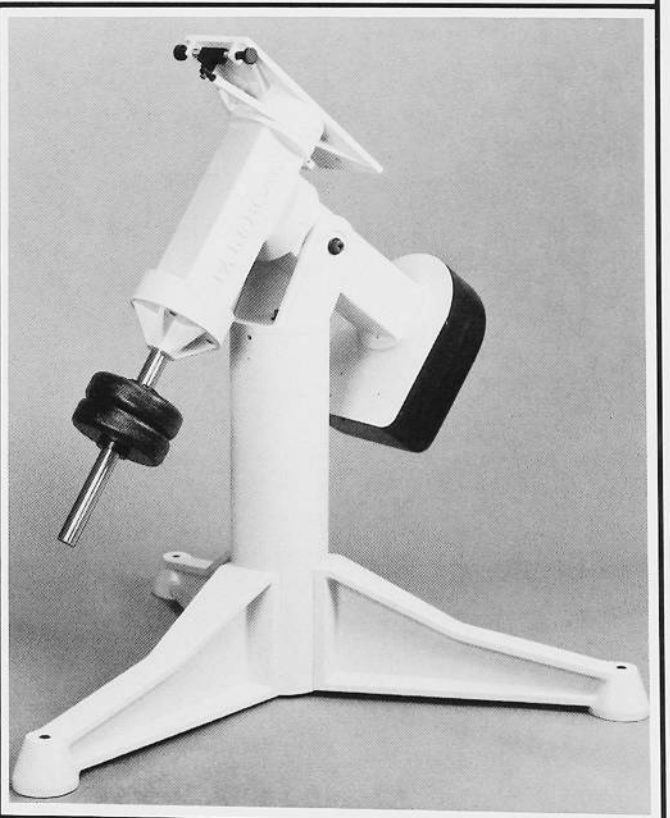

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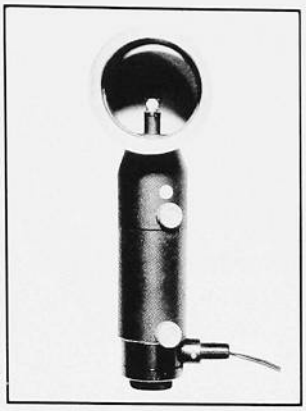

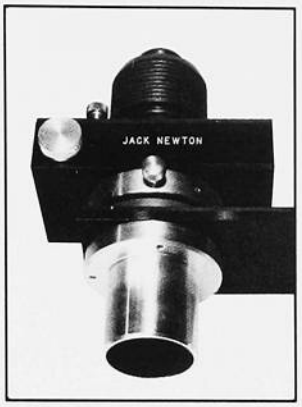

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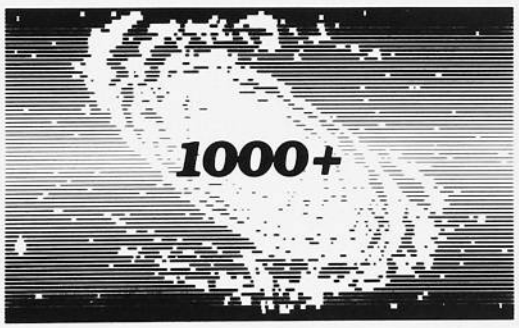

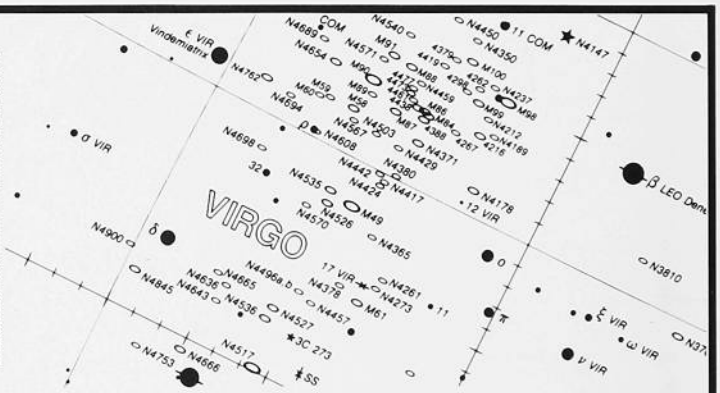

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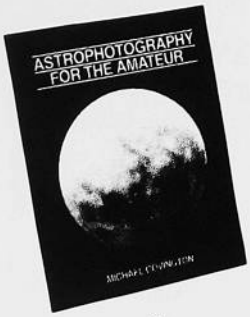

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